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GROWTH AND DEVELOPMENT OF THE CEREBRAL CORTICAL PATTERN IN MAN

OSCAR A. TURNER, M.D.
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THE FISSURAL pattern of the cerebrum is the result of an uneven growth process. The progress of expansion in the various portions of the hemisphere is reflected in the complexity of the cortical pattern in the same regions. Similarly, those changes in the complexity of the cortical pattern which occur with advance in age are related to the tempo of growth and expansion in any region or lobe of the brain. The present study is an attempt to interpret the progress of growth and development of the various portions of the human cerebrum by observations on the changes which take place in the cortical pattern from late prenatal to early adult life. This work is a continuation of the program for the study of growth and development initiated by the late Dr. T. Wingate Todd. Dr. Todd's untimely death and the return of Dr. Y. T. Loo to China delayed publication of the portion of the program given over to the study of the central nervous system. While Dr. Todd and Dr. Loo must be credited with carrying out the major portion of the work, attempts to locate Dr. Loo have been unsuccessful, and, in publishing the material it is felt that such interpretations as are given may not necessarily correspond with those which either Dr. Todd or Dr. Loo entertained. The age changes occurring in the brain were traced by stages from the late intrauterine period to the age of 20 years. This paper concerns only the changes in the cortical pattern, and the correlation of these changes with the surface area, weight and volume of the brain will be considered in another publication.

For the present study, a series of 39 brains at stages from birth to 20 years of age were used. For purposes of discussion and illustration, the developmental process has been divided into three stages: (1) late intrauterine appearance, between the fetal age of 7 months and birth, (2) early postuterine appearance, between birth and 2 years of age and (3) late postuterine appearance, between about 2 years of age and adult life. These stages will be referred to as the fetal, early

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postuterine and late postuterine stages, respectively. It is obvious that these stages are neither exact nor sharply defined, and as such are to be considered as purely arbitrary divisions of a constantly changing pattern, in which no single feature or stage exists in an isolated form. The progress of growth and development will be followed in each lobe of the brain separately, and reference will be made to the schematic and composite drawings illustrating the essential features of the cortical pattern at each of the three stages in development. Of the 39 brains, 1 was used for the study of what has been termed the first stage, supplementary data having been obtained from Retzius ("Das Menschenhirn"[1]). It is to be noted that the figures in Retzius' book refer only to fetal and adult material, there being no illustrations of children's brains. For the study of the second stage, 22 brains were used, and for the last stage there were 12 brains. All brains in the series were carefully examined and exact drawings made to scale. The finer ramifications of each of the sulci were completely mapped and notes made on all points of pertinent detail. All sulci were identified and their relations to adjoining sulci determined.

GROWTH PATTERN OF THE LATERAL ASPECT OF THE FRONTAL LOBE

The frontal lobe of the brain is referred to in its broadest sense, including all the lateral surface of the cortex anterior to the central sulcus and, in its posterior portion, the region above the sylvian fissure (lateral sulcus).

Fetal Stage (fig. 1).—At this stage the precentral sulcus is subdivided into an upper and a lower part, and from each there is a branch forward, a horizontal portion connected with the ascending, or vertical, portion of the precentral sulcus. The horizontal portion in each instance appears as two separate sulci. The horizontal rami are the sulcus frontalis superior and the sulcus frontalis inferior, respectively, and between them is an area of cortex which is to expand later and form an operculum over the sulcus frontalis inferior. Within this rapidly growing area, and near the frontal pole, is a small horizontal sulcus, the commencement of the sulcus frontalis intermedius. At this stage it has a forward extension, which is directed downward and terminates posteriorly in a division of small size.

Early Postuterine Stage (fig. 2).—At this time there is a much more extensive precentral sulcus, which has the same superior and inferior portions as before, but there has appeared a small, isolated sulcus, the sulcus precentralis marginalis, which carries the line of the superior precentral sulcus toward the vertex. The lower part of

1. Retzius, M. G.: Das Menschenhirn, Stockholm, P. A. Norstedt & Söner, 1896.

the precentral sulcus is extended upward by a furrow, not entirely in line with it, toward the upper part of the precentral sulcus. From the upper and lower portions of the precentral sulcus the corresponding horizontal extensions branch arteriorly, and the original separation into two parts seen at an earlier age is no longer present. The inferior one, indeed, shows about halfway along its course a small, upwardly directed branching sulcus.

The sulcus frontalis intermedius is now more extensive than it was previously. Its posterior branching termination has developed into an almost vertically placed sulcus, owing probably to the development of the cortex immediately behind it (motor area). The anterior, downwardly directed extension of the former stage is now subdivided. Anterior to this sulcus, between it and the frontal pole, are two small, isolated and vertically placed sulci.

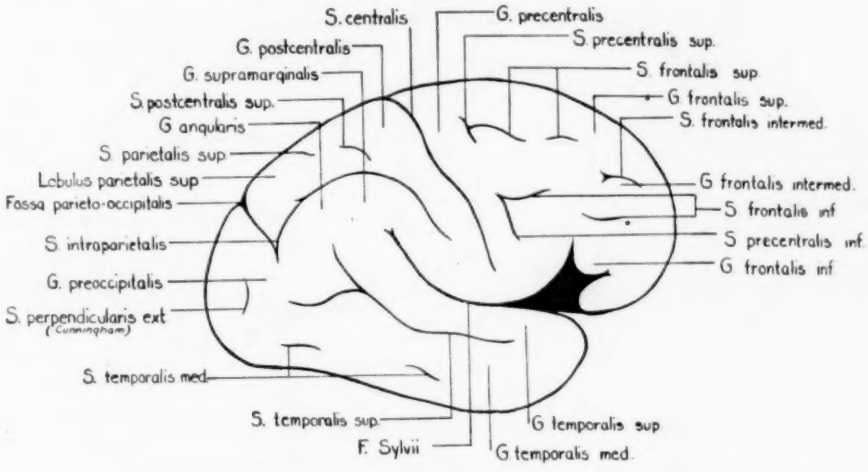

Fig. 1.—Schematic diagram of the lateral surface of the fetal brain from about the seventh prenatal month to birth.

The stem of the sylvian fissure is now completely operculated. The frontal operculum has grown sufficiently to fill in the gap between the frontoparietal and the orbital operculum.[2] The frontoparietal operculum has a slight subdivision, the sulcus diagonalis, which passes upward in line with, and probably forms part of, the general direction of the sulcus precentralis inferior. Behind the sulcus diagonalis there

2. There has been some discussion concerning the development of the insular area at the time of birth, and Connolly [3] commented on the completeness with which the insula is covered at this stage. In my experience, the neonatal brain generally exhibits a variable degree of uncovering of the insula. While it is generally stated that opercular development sufficient to cover the insula occurs during the first year of postnatal growth, it is probable that there is some variation in the tempo of growth in this region.

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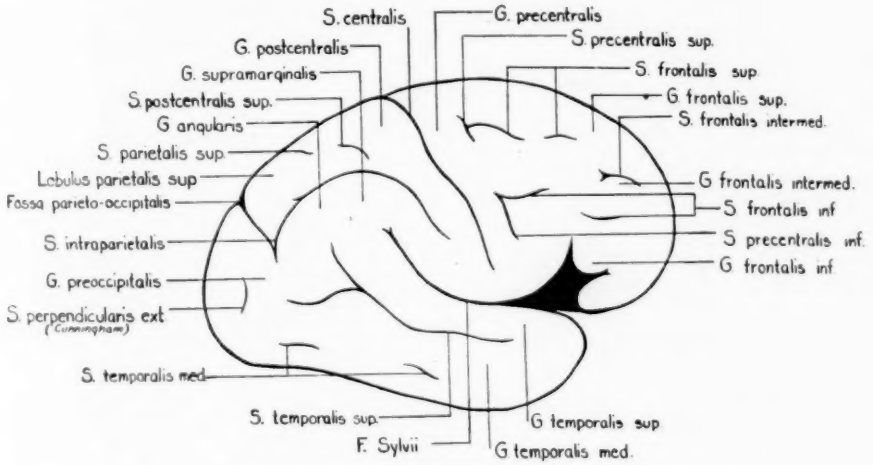

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is also another small notch, the sulcus subcentralis anterior, which outlines the anterior limit of the gyrus subcentralis.

Late Postuterine Stage (fig. 3).—There has been now definite enlargement of the frontal lobe over the previous stage, and the various fissures have become more complex than before. The precentral sulcus is subdivided, of course, into the superior and inferior components. Between the two there has appeared a sulcus precentralis medius, which is inconstant and probably develops in a few brains only for relief of unusual tension. The sulcus precentralis marginalis of Cunningham, which appeared in the previous stage, has changed direction, in conformity with the increase in the upper portion of the frontal lobe, and

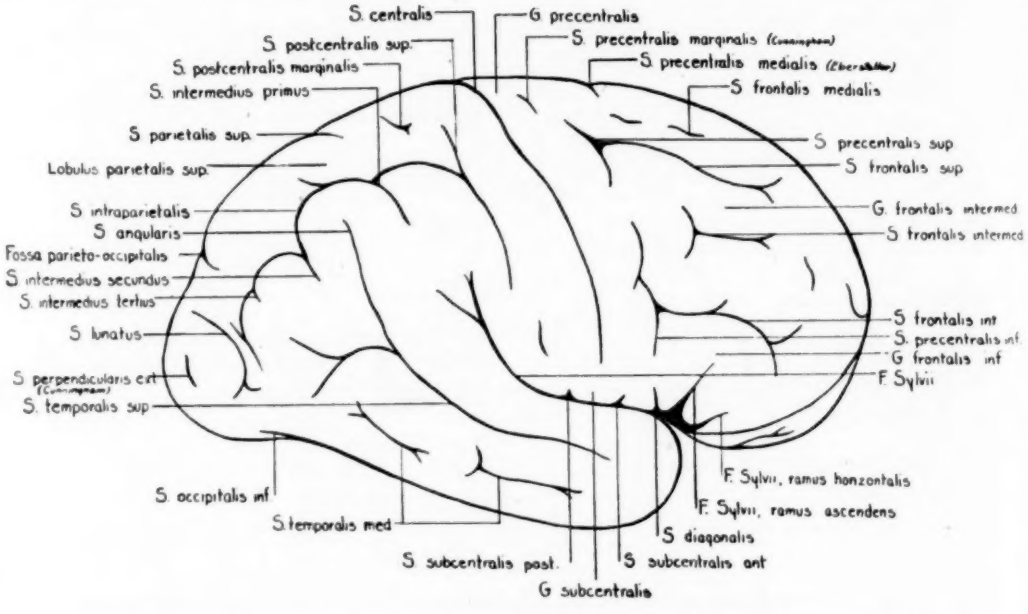

Fig. 2.—Schematic diagram of the lateral surface of the brain from birth to about 2 years of age.

now lies almost horizontal. However, it is to be noted that the upper end of the sulcus precentralis superior has also been directed backward, in accordance with the prefrontal expansion. The horizontal portions of the fissures are extraordinarily long and complex by comparison with the previous figures. The sulcus frontalis superior and the sulcus frontalis inferior (primus and secundus of Cunningham) are both elongated and both connected with the corresponding precentral sulci. Each has numerous branches. Between them lies a greatly extended sulcus frontalis intermedius, which has a definite transverse tail at each extremity. The small, isolated sulci between this and the frontal pole have increased in number. The sulcus frontalis medialis has

extended in length and its portions never join to form a single running sulcus. The sulcus precentralis medialis (Eberstaller) remains about the same as before, but an extra sulcus branches off from the sulcus precentralis inferior.

The area over the stem of the sylvian fissure is much more complex than it was, and there is obvious squeezing of the various operculums. The orbital operculum now shows a distinct horizontal ramus and running into this operculum is the free branch of the termination of the sulcus frontalis inferior. The limb of the termination directed toward the frontal pole is known as the ramus ascendens. There is little change in the gyrus subcentralis, which has its delimiting sulci

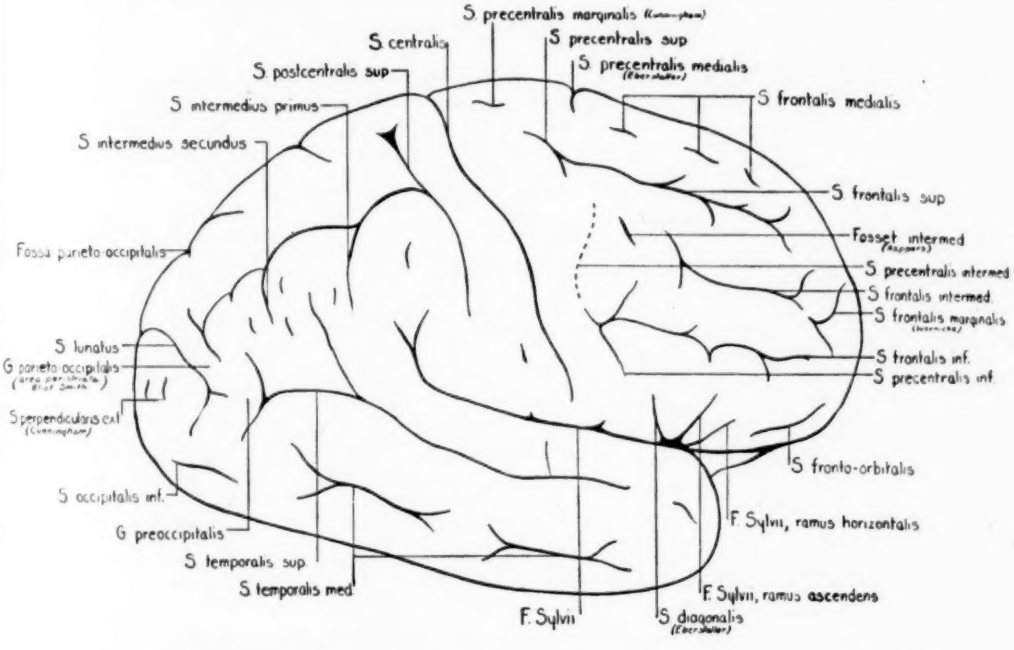

Fig. 3.—Schematic surface of the lateral surface of the brain from about 2 years of age to the adult stage.

in front and behind, as before. However, there is a notable increase in the size of the frontoparietal operculum and also of the frontal operculum on either side of the sulcus diagonalis. So large has the former become that the sulcus precentralis inferior now passes down into its midst.

For relief of tension close to the frontal pole, there has developed a sulcus frontalis marginalis (Wernicke), which acts as the anterior branching termination for the sulcus frontalis intermedius, but is not actually connected with the latter.

The frontal lobe, as can be ascertained, shows definite growth and development practically through to adult life. The growth is at

a moderate pace up to the age of 2 years. The most vigorous growth, however, occurs between the ages of 2 and 6 years, and the submaximum is attained at the age of 10 years, as in the parietal lobe. Of particular note is the relative enlargement of the lobe as a whole. This occurs during the third stage with the development of many small, isolated sulci and complex branchings of the previous simple cortical fissures to relieve tension of the rapidly expanding cortex.

GROWTH PATTERN OF THE LATERAL ASPECT OF THE TEMPORAL LOBE

By the temporal lobe is meant that portion of the lateral surface of the hemisphere below the fissure of Sylvius, extending as far back as the level of the posterior margin of the gyrus angularis.

Fetal Stage (fig. 4).—At this stage the parallel, or superior, temporal sulcus is well formed as a running fissure which has a branched termina-

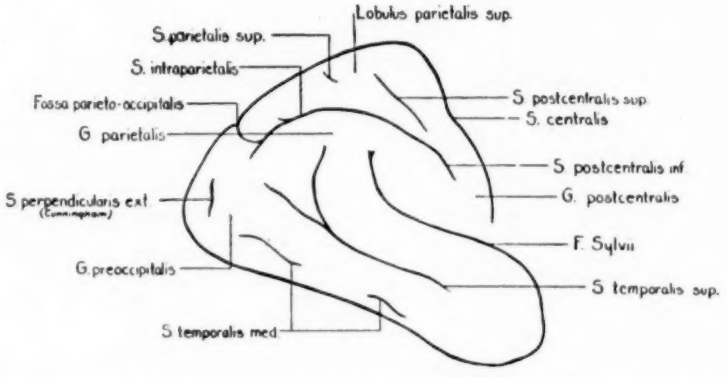

Fig. 4.—Schematic diagram of the facies lateralis postcentralis of the brain from about the seventh prenatal month to birth.

tion posteriorly. The upper division of this termination, together with the blind end of the fissure of Sylvius, is capped by a single gyrus, which later in development consists of two gyri, the supramarginalis, in front, and the angularis, behind. At this stage there is no distinction between the two. The lower division extends almost horizontally backward and appears to pass into the occipital cortex. The sulcus temporalis medius consists of two separate, isolated sulci, parallel with the sulcus temporalis superior. The temporal pole extends approximately to the incomplete orbital operculum, but the whole temporal lobe appears thin and attenuated (fig. 1).

Early Postuterine Stage (fig. 5).—At this stage there has been considerable development about the posterior portion of the temporal lobe, part of which will be described in relation to the changes in the parietal lobe. The posterior end of the sylvian fissure has divided,

and the lower limb of the terminal division of the superior temporal sulcus has done likewise, forming a terminal secondary branching. The lower limb of this secondary division projects down into the lower part of the occipital area, while the upper limb has a new development about it, namely, the gyrus postparietalis. The sulcus temporalis medius is still composed of two isolated sulci, but now each has a small subdivision anteriorly and posteriorly. The temporal pole has scarcely developed beyond the previous stage and projects no farther forward than it did (fig. 2). The only significant change in this region has been referred to, namely, the filling in of the stem of the sylvian fissure, owing to the increase in the size of the operculums above the temporal pole.

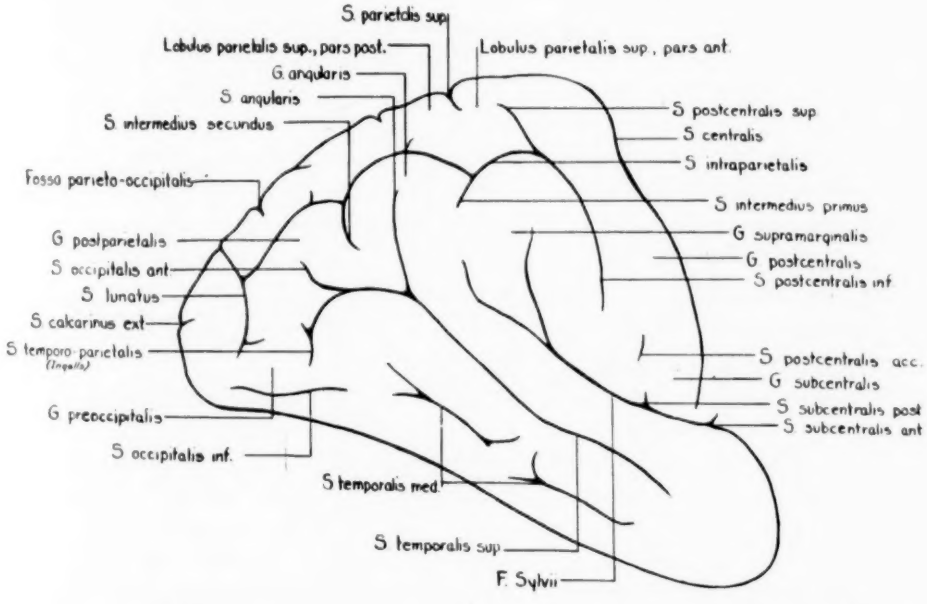

Fig. 5.—Schematic diagram of the facies lateralis postcentralis of the brain from birth to about 2 years of age. This illustrates a somewhat less advanced stage than that seen in figure 2.

Late Postuterine Stage (fig. 6).—At this stage there is evidence of posterior expansion, with local development about the sulcus occipitalis inferior. The temporal pole, however, shows great expansion and has extended forward, so that it now reaches almost midway along the orbital surface of the frontal lobe (fig. 3). The function of this area is not clear, but the tremendous increase after the second year of life is apparent.

The greatest development and the most significant growth changes in the temporal lobe occur at the posterior portion of the lobe and are

closely related to the changes which take place in the parietal and occipital regions. In the temporal lobe, as in the occipital, there is an initial rapid increase in the area after birth. The latest growth occurs in the temporal pole at about the age of 5 years.

GROWTH PATTERN OF THE FACIES LATERALIS POSTCENTRALIS

The facies lateralis postcentralis is taken to include that portion of the lateral surface of the hemisphere posterior to the central fissure and including the occipital lobe. There is a close relationship between the posterior portion of the parietal lobe and the occipital region, and growth changes in these regions must be considered together. Also included is a discussion of certain changes, not already referred to, which occur about the posterior portion of the temporal lobe.

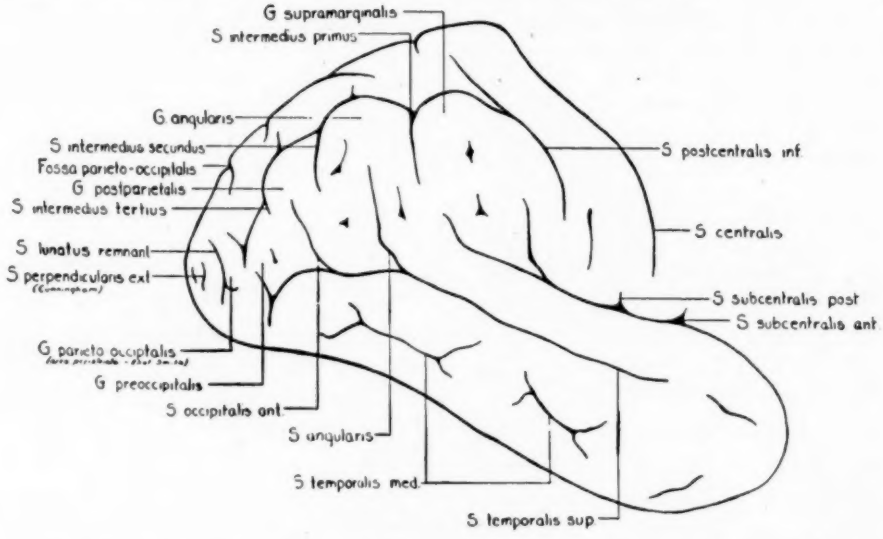

Fig. 6.—Schematic diagram of the facies lateralis postcentralis of the brain from about 2 years of age to the adult stage. This illustrates the more usual pattern than that shown in figure 3.

Fetal Stage (fig. 4).—At this stage the sylvian and superior temporal fissures are together capped by a simple, semilunar sulcus, which ends posteriorly in a branching fashion. The upper limb of this subdivision terminates in the parieto-occipital fossa (fig. 4), while the intraparietal fissure itself presents no subdivisions or interruptions, as it does later in life. This fissure actually consists of the inferior postcentral sulcus, anteriorly, and the intraparietal sulcus, posteriorly. The superior postcentral sulcus is distinct from the inferior. The superior parietal lobulus is relatively small and is separated from the postcentral gyrus by a small and isolated superior postcentral fissure.

In the superior parietal lobule is to be seen the small, isolated superior parietal sulcus.

A definite sulcus lunatus has not been observed at this stage, nor has its antecedent, if any, been identified. The latter is probably represented by the superior parieto-occipital fossa. On the occipital pole, behind the parallel, or superior, temporal sulcus, are three small, isolated sulci, the largest and most inferior being the inferior occipital sulcus. Above this may be observed another isolated sulcus, which probably unites later with the parallel sulcus. On the extreme occipital pole is a vertically placed furrow, the sulcus perpendicularis (Cunningham), which may be seen in all three stages of development.

The sulcus lunatus actually forms part of the great fossa parieto-occipitalis, the latter actually indicating an operculum which covers part of the potential parietal cortex. This accounts for the absence of the lunate sulcus at this stage of development.

Early Postuterine Stage (fig. 5).—At this stage there has been considerable change, with isolated or irregular expansion of different areas. The intraparietal sulcus is now practically subdivided into three, so that it caps individually the sylvian, the superior temporal and the occipital anterior sulcus. In doing this, it surrounds or outlines the supramarginal, the angular and the postparietal gyrus respectively. The superior postcentral sulcus has now joined the inferior postcentral and intraparietal sulci. More branching sulci appear in the superior parietal lobule. The middle temporal sulcus now appears to be in line, interruptedly, with the inferior occipital sulcus. A sulcus lunatus appears on the extreme occipital pole.

The presence of a division terminating the sulcus intermedius tertius, the latter forming the posterior boundary of the postparietal gyrus, indicates the elevation of cortex from under the occipital operculum, and thus the lateral margin of this operculum, namely, the sulcus lunatus, is clearly and separately defined. There is considerable space at this stage between the fossa parieto-occipitalis and the sulcus lunatus, and in the midst of this newly elevated cortex is visible the subdivision to which reference has been made. The sulcus lunatus, therefore, is clearly demonstrated at this stage and is an indication of the rapid and tremendous cortical expansion which has occurred.

Late Postuterine Stage (fig. 6).—At this stage there is still evidence of the progress of the growth process beyond the second stage, and the various convolutions, struggling to obtain sufficient space, form a more complex pattern. There have been an increase in the number of isolated sulci and a confluence of these in some places to form more running fissures. The exaggeration of the supramarginal, angular and postparietal gyri is intensified, and the extension of the superior temporal sulcus posteriorly toward the occipital lobe is well marked.

There has been relatively little change in the superior parietal lobule or in the relation of the superior postcentral sulcus to other sulci in this region. There may be no evidence of the sulcus lunatus at the occipital pole, or there may be a reduced fissure, consigned almost to the pole itself, representing the remnant of this sulcus. It is to be noted that the postparietal gyrus has extended toward the occipital pole, this extension being known as the preoccipital gyrus. It is probable that the appearance of this gyrus has resulted in the elimination of the lunate sulcus complex. With the extension of this portion of the cortex and its elevation to the surface, the area striata is relegated to the pole or to the medial aspect of the lobe, and there is subsequent elimination or disruption of the sulcus lunatus complex. A comparison of figure 5 and figure 6 will make this clear. In figure 6, behind the area preoccipitalis is another area, called by Elliot Smith the area peristriata, and beyond this, again, can be seen the remnant of the sulcus lunatus.

The sulcus lunatus is to be clearly seen at this stage in many brains, but the separation of this sulcus from the fossa parieto-occipitalis by the newly elevated cortex is the dominant feature in the developmental changes occurring in this part of the brain. This newly elevated cortex partially subdivides the gyrus postparietalis by a further elaboration of the sulcus intermedius tertius, and in the separated portion, the gyrus preoccipitalis, there appears an isolated sulcus. The sulcus lunatus is gradually pushed toward the occipital pole, as has been noted, and on the cortex between it and the pole itself can be seen the sulcus perpendicularis externus of Cunningham, to which reference has been made.

There are further increasing tension and expansion of the posterior portion of the temporal lobe, associated with the development of the gyri which cap the subdivisions of the sylvian and post-temporal sulci (fig. 6). The sulcus occipitalis inferior in the previous stage appeared as a small fissure running from the under surface of the temporal lobe upward and backward, so that it reached the region of the lower end of the sulcus lunatus posteriorly. It was visible on the outer surface, just below, to the lowest branch of the posterior termination of the sulcus temporalis superior. At this stage, however, the inferior occipital sulcus is almost completely on the lateral aspect of the temporal lobe, an indication of vertical expansion of the temporal lobe below the sulcus temporalis medius, at least in its posterior portion (fig. 3).

In the parietal lobe, there is a period of vigorous expansion between birth and the age of 2 years, with subsequent slower growth to a submaximum at about 10 years. The greater part of the developmental process is attained by the age of 6 years. The occipital lobe, like the temporal, shows an initial rapid increase after birth.

COMMENT

It is interesting to note that throughout the period of growth there is little change in the fundamental fissural patterns of either the occipital or the temporal lobe. These, at the time of birth, have present the surface markings of most of the sulci to be (figs. 1 and 4). The most important change in the occipital lobe is that involving the sulcus lunatus, the mechanism of which has been discussed. In the anterior portion of the temporal lobe, the changes are slight and consist in the development of secondary sulci and subdivisions of the fissures already present. This process, here as elsewhere, is a mechanical means of relieving tension which results in greater surface area with little increase in actual size. A comparison of the final picture (fig. 5) with that seen at birth, or even shortly before (fig. 4), reveals the fact that the secondary changes have not been great and that the fetal pattern has not been overshadowed by the secondary changes. Indeed, failure of the preoccipital gyrus to develop fully and extend to the surface, as indicated by the persistence of the lunate sulcus, is not an uncommon observation in the examination of a large number of adult brains.

Certain late changes do take place in the temporal lobe, however, and these consist essentially in the vertical expansion of the posterior portion of the lobe and the forward extension of the pole. The former change is undoubtedly associated with the changes in the region of the preoccipital cortex.

The relatively small degree of morphologic change which occurs after birth in these two regions suggests that the period of most active growth or differentiation is at birth or shortly after, and that the changes which do occur later are to be considered dependent on the changes in the adjoining region, namely, the highly active temporoparietal cortex.

The upper lip of the sylvian fissure, just posterior to the region of the operculums, is another area in which the changes occur over a short space of time. In the earliest period studied here, this upper lip is smooth and free from significant secondary infoldings (fig. 1). In the later stages, however, and persisting unchanged throughout the later course of development, there are two small and rather inconspicuous, but nevertheless constant, sulci, the sulcus subcentralis anterior and the sulcus subcentralis posterior (fig. 3). Once having developed, their relation to the lower end of the fissure of Rolando is rather constant. The associated insular area shows no such complete early development. This, and the forward extension of the temporal pole, constitute an important factor in the development of the facies lateralis precentralis.

Thus, the area forming the upper lip of the sylvian fissure behind the developing insular operculums has a rather restricted period of growth, from the morphologic standpoint beginning some time between birth and the age of 2 years and terminating well before the adult stage

is reached. This restriction of the growth period can be ascertained from the relatively simple character of the change, and it is only by association with the complex and rapid alteration taking place in the insular area that development in this location assumes large proportions.

At the time of birth, the facies lateralis precentralis is rather simple, presenting a few surface indentations which are uniform in outline and present no special complications (fig. 1). From the standpoint of their morphologic future, however, the region is complex. When this picture is compared with that seen at the end of the first two years of postnatal growth (fig. 2), the presence of running fissures, secondary sulci and further exaggeration of various parts of this area make it apparent that at the time of birth the frontal region is relatively poorly developed. Nevertheless, at the end of two years the basic pattern is still apparent; and although the changes associated with rapid cortical expansion are present, they are incomplete and not accentuated. The gyri are rather wide; the fissures, although well marked, are relatively poor in secondary infoldings, and the insular operculums are incompletely developed and only become sufficiently formed to cover the insula completely after the second year (fig. 3).

It is apparent that, although there is rapid differentiation to form the essential features of the adult pattern beween birth and the age of 2 years, it is only after 2 years of age that the developmental details of the adult picture appear to take form in the frontal region. This region, then, attains its mature pattern somewhat late in development.

The postcentral region, surprisingly simple at the time of birth (fig. 4), becomes complex later in life. The appearance of the intermediate sulci as secondary infoldings from the intraparietal sulcus and the elaboration of the posterior terminations of the sylvian and superior temporal fissures by the end of the second year (fig. 5) make obvious the considerable development of this region from the time of birth. The close relationship of the sulcus intermedius tertius to the lunate sulcus indicates not only that the development here is incomplete at this time, but that the changes are in a large part dependent on the activity of the still sunken preoccipital cortex and that the final development of this region occurs late. In this connection it is of interest that Connolly [3] has shown that in the Cercopithecidae the presence or absence of the lateral, or external, calcarine fissure is dependent on the development of the neighboring cortex. It is this interdependence which probably accounts for the variety of patterns in this region, and it seems likely that changes, minor in degree, occur in this region even in early full adult life.

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3. Connolly, C. J.: The Fissural Pattern of the Primate Brain, Am. J. Phys. Anthropol. **21**:301-422, 1936.

RELATION OF PERSONALITY PROBLEMS TO ONSET AND PROGRESS OF MULTIPLE SCLEROSIS

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A CERTAIN group of patients with multiple sclerosis show personality problems at the onset or during the course of the disease. In some cases the symptoms develop or increase during periods of turmoil in interpersonal relationships. This report considers the relation of emotional conflict to the development and progress of the disease. Even after the organic changes are clearly manifest, the patient may complain of symptoms which are largely or purely functional in nature.

It has long been conceded that persons with well developed symptoms of multiple sclerosis show emotional instability. This has been explained as due to organic changes in the brain, releasing more labile emotional patterns. The syndrome of pseudobulbar palsy may be fully developed. Some years ago my colleagues and I (Langworthy, Kolb and Androp [1]) reported psychotic trends which appeared during the organic illness and were often severe enough to require hospitalization.

The neurologist is frequently confused at the time of onset of the first symptoms as to whether they have an organic or functional basis. It has always been apparent that poor emotional adjustment was a problem in many cases of multiple sclerosis even before the symptoms of organic disease developed. In these instances the patients may be emotionally immature and show this immaturity in all their interpersonal relationships. It is often seen particularly in their sexual adjustment, which can be evaluated at a preadolescent level of emotional growth. The diagnosis of hysteria is frequently made at the onset of the symptoms, not alone because of the bizarre nature of the complaints but especially because of a personality structure consistent with this diagnosis. Later, when objective signs of organic cerebral damage appear, the diagnosis is abruptly changed to multiple sclerosis. In this report, I should like to focus attention on the place where the attention turns from emotional to organic issues. The emotional factors must still be operative in the patient, even though damage to the central nervous system has occurred. Is it possible that the personality problems are

From the Henry Phipps Psychiatric Clinic.

1. Langworthy, O. R.; Kolb, L. C., and Androp, S.: Disturbances of Behavior in Patients with Disseminated Sclerosis, Am. J. Psychiat. **98**:243-249, 1941.

factors in the development of the changes in the central nervous system? It would be logical to consider how much of the illness is functional and how much is organic, and what the relationship between these two factors may be. There is precedent for abandoning the old concept that the patient either is hysterical or has a well defined organic disease.

Frequently, symptoms of hysterical conversion develop in patients who already have clear objective signs of multiple sclerosis. As an example, in a patient who had shown symptoms of multiple sclerosis for twelve years there developed pronounced ptosis of the eyelids with a continual sensation of fatigue and tendency to sleep during the day. The difficulty in holding his eyes open interfered with work and pleasure. It was a problem for him to drive a car. Careful ophthalmologic and medical studies revealed no organic basis for these symptoms. It was easy to postulate a symbolic basis for his inability to keep the eyes open. He did not wish to look at the fact that his marriage was a failure and his wife was untrue to him.

There are a few patients who become aware themselves that periods of emotional turmoil tend to bring on new disabilities characteristic of multiple sclerosis or to accentuate symptoms which are already present. It has been recognized for a long time that any unusual strain on the body may bring on or accentuate the symptoms. The onset or exacerbation of the process may be related to pregnancy or to an acute infection. It appears that emotional factors which put a strain on the body may act in a similar way.

The case reports which follow are designed to illustrate some of the previous statements. They attempt to present the attitudes and trends which make up the personality structure in the particular case and suggest the relation of emotional stress to the development of symptoms.

REPORT OF CASES

Case 1.—H. C. S., a married woman aged 32, came to the hospital for an evaluation of her organic difficulties and a consideration of her relationship with her husband and her family. She had left her home state and was considering permanent separation from those close to her.

At the age of 17 years sudden blindness developed in the right eye. This followed an appendectomy by three months. It also occurred at a time when she was disappointed in her desire for a college education because her father had had financial reverses. There were periods of blindness off and on for the next four years. No diagnosis was made.

She felt quite well when she married, at the age of 21, and had good health until she was 26. Then she noticed paresthesias of the extremities, heaviness of the right arm and awkardness of the legs. The symptoms appeared when she gave up her secretarial position and prepared to move with her husband to another city, away from her family. The physician made the diagnosis of multiple sclerosis and talked over the situation with an older sister, who was a nurse. The patient was told "never to have children or sicknesses and not to get tired."

She resented the effort to protect her and became angry with her sister, who had failed to tell her the facts concerning her illness.

Her symptoms became particularly severe in the summer of 1946. At times her vision was blurred and hazy. Paresthesias occurred in her arms. Her legs were weak and unsteady. Relations with her husband had been strained for the past year, and she felt that she could not go on with the marriage. The symptoms were worse when she attempted to care for a garden, a job which she felt was her husband's responsibility.

On neurologic examination she appeared thin, worried, tense and overactive. Both optic disks were flat, and the right disk was pale. There was sustained nystagmus on looking to the left. At times the patient slurred certain words. Gait was awkard, and there was a tendency to drag the right leg. Moderate ataxia was present in both arms, especially the right. The extremities were red, mottled, cold and moist. The deep reflexes were overactive bilaterally, and the Babinski reflex was elicited on both sides. The abdominal reflexes were absent. There was a tendency to urgency of micturition and defecation. No sensory abnormalities were found. The serologic reactions of the blood were negative for syphilis. The spinal fluid was examined in another hospital and said to be normal.

The patient was the younger of 2 girls, born in a family in which the members demonstrated little affection. She stated that she was like her mother in temperament. Her mother was described as interested in money and social position, and as subject to emotional outbursts when her children did not follow her instructions. "I was made the boy of the family by my father. He was soft hearted, and I went everywhere with him. I used to swing a baseball bat. My father always gardened. I was a tomboy." She described her sister as more feminine, and as one who would "enjoy a lace negligee." She felt that the four of them had different temperaments, and she was never happy in the home.

As a child, she was always told not to do this or that and not to get hurt. She resented the strict rules that her parents made for her. Her sister used to break these rules, but the patient always conformed. After finishing high school, she obtained a responsible secretarial position with an old friend of her family. This work gave her great satisfaction, and she continued in this position for five years after her marriage.

She first resisted the family opinions when she married a man of whom her mother and sister did not approve. She herself considered him her social and intellectual inferior. She was cold sexually and unresponsive in all emotional situations. She still resents his sexual approach on their wedding night. She never wanted children and had never become pregnant.

There is evidence that the patient became more resentful and her somatic symptoms increased as her husband prospered and obtained better positions. During the past year he had been busy establishing his own business and had given little time to his home. He gave his wife less emotional support and attention. She felt little confidence in his business judgment and took pride in the fact that she could "think circles around him."

Certain of her statements explained her attitude. "I have rebelled at so many things I have not liked, and I have hated so many things." "Things people tell me I cannot do, I am bound to do." "The way my husband hurried through his meals burned me up." "I never felt much security in my life."

About two weeks after I saw her, the patient's symptoms increased. She related these symptoms to a cold, onset of menstruation, a job which was too much for her and a visit from her husband. In subsequent interviews, she

continued to give vent to her hostility toward her husband, sister and mother. She felt that she would be quite happy living alone, without any close friends, and considered opening a dress shop. She resented the fact that her father had not been able to send her to college. She also was annoyed that her husband had had an opportunity of a college education but did not avail himself of it.

In summary, this woman was a neurotic child, and it is probable that the early attacks of blindness were considered hysterical. Certainly, there are many aspects of her personality which would support the impression of a hysterical personality. Now she shows clearcut signs of organic disease of the nervous system consistent with the diagnosis of multiple sclerosis. She is a tense, hostile, driving woman, and her anxiety is manifest in the pronounced vasomotor instability.

Her father, disappointed that he had no son, made the patient his companion and encouraged her to be a tomboy. She patterned herself after her father and was impatient of the restrictions placed on her by her mother and older sister. The disappointment of not having a college education seemed to her to put a check on her aggressive intellectual drives. She was happy in a responsible job which brought out her capabilities.

As a gesture of independence of her family, she married a man of whom they did not approve. She considered him inferior from an intellectual and a social point of view, but she felt that she could mold him and help him. Sexual adjustment was never satisfactory. She became increasingly uneasy as her husband became more secure. The somatic symptoms have become accentuated at periods of emotional tension.

Her husband said that he loved her and wanted to take care of her. The patient resented any thought of giving in to her illness and insisted that she must be independent. A passive acceptance of her limitations was completely unacceptable to her. Later her husband arranged for an annulment of the marriage.

This patient returned for fourteen conferences. At the end of this time she felt that she could deal with her problems in a more realistic manner. Her symptoms of multiple sclerosis were less severe, and she entered a period of almost complete remission. She sought for suitable work.

CASE 2.—S. W., a married schoolteacher aged 27, when seen first on June 30, 1941, complained of weakness of her left arm and leg. A year earlier she had first noticed awkardness of her left hand, which caused her to drop things, and she had to stop playing the piano. She recovered use of her arm in six weeks, but later her left knee gave way when she walked. On examination she seemed euphoric and said that her spirits were "remarkable." The right pupil was somewhat larger than the left. There was nystagmus on looking to either side. The patient tended to slur test phrases. There was a tendency to drag the left leg. Awkardness in performing delicate movements was noticed in both arms. Ataxia in the heel to knee test was demonstrated on both sides, especially on the

left. The Babinski reflex was elicited on the left side. The diagnosis of multiple sclerosis was made.

At the time of her next visit, in January 1943, she was anxious, tense and emotional. During the interval she had been well and had continued with her teaching. A therapeutic abortion had been done two months earlier because her physicians thought that pregnancy was unwise. A week before her visit weakness and intention tremor developed in her right arm, and she felt that this condition would interfere with her work.

During this period she showed her resentment toward me in many ways. She discounted her bill, saying that she felt that it was too large. She introduced herself to me on a bus and got off at another hospital, where she obviously sought advice. Later, she wrote a long letter to another psychiatrist, saying that she would like to consult her but felt she must return to me.

Finally, she returned in October 1944, because she had lost her ability to speak in many situations. She was highly excited and brought me a long letter to explain her troubles. She said that she could not speak to people whom she liked, and she was so fond of me she was sure she could not talk. She said, "I know I can speak, but mainly I don't want to." She said that she was able to speak normally after drinking alcohol. She was resentful because I had approved of the abortion. She was taking histamine treatments for multiple sclerosis in another hospital. In discussing her speech difficulty, she said that she had always obtained a great deal of pleasure from speaking in public. "Life is a show. I played to the public. I thought people did not mean anything to me." She was eager to enter the hospital to consider the speech problem.

Her first stay in the Phipps Clinic was of eleven days' duration. She felt superior to the other patients and thought she was not so sick as they were. She was unwilling to participate in the hospital activities but liked to start intellectual conversations about the latest books. She left the hospital against advice because she said she could not adapt herself to the treatment situation. The symptoms were increased as soon as she left the hospital. This exacerbation was precipitated by her husband's telling her that she was stubborn and childish in her attitude. She became depressed and thought of suicide. She was readmitted for a three months' stay.

She was a pyknic woman, with small breasts and facial and pubic hair of a male distribution. Central vision was decreased in the right eye, and the right optic disk was pale. The gait was unsteady, owing to a tremor of the left leg. There was ataxia of the extremities. Test phrases were spoken explosively. In emotional situations speech was extremely difficult, owing to muscle spasm.

She talked a good deal of her foreign-born, Jewish parents. "I am like my mother. She has a stoic complex—a martyr. She is very intelligent. I have always admired my mother's characteristics." She said, "my father has gotten on the whole family's nerves because he keeps complaining about his arthritis. If he had not been so stubborn and had listened to mother's advice, he would not have lost all his money." The 3 children supported the parents. The oldest was a brother who "evades responsibility and is very weak, like father." The sister, who was older than the patient, was unmarried and had marked mood swings. She was more like her mother.

The patient was an unwanted child, who identified with her mother and strove for intellectual superiority. When she was 15, her father lost his money. This made a college education impossible, and she accepted normal school training, with strong resentment. At the age of 18 she married a man whom she met on the street corner and whom she considered intellectually inferior to her-

self. The patient always looked for the best in the "intellectual line." She had to go to the best plays and read the best books. When she was 24 and 25 years old, she was president of the Junior Hadassah, a national feminist Zionist organization. Speech making was her *forte,* and it was done with ease. During the next year she had to join an older group, where she was insecure because of their greater prestige and was never outstanding.

This socal insecurity was one of the problems which she faced at the age of 26, when the first signs of multiple sclerosis developed. Also, at that time her husband surpassed her in earning power and showed other increasing capabilities which were a threat to her. At the same period she began to go off by herself for a month each summer. On each of these occasions she had an affair with a man whom she met on the trip. She looked for and enjoyed "intellectual male companionship." She said, "I asked several of them what they found so attractive in me, and they said it was my understanding nature."

The onset of speech difficulty in 1944 followed the last of these extramarital affairs. She found that the man was married, and his wife learned about the romance. She retaliated in a way which threatened the patient's home and teaching position. The patient lived in dread and fear of the telephone and doorbell because it might mean blackmail. She lost her speech and could not talk over the phone. After her return to the hospital, discussions concerned themselves with her need for superiority. She felt completely uncertain of her attitude toward her husband and her family. She was concerned with the question whether she had difficulty in speaking because she was still trying to make an impression or whether she was hiding something she did not want to say. She wrote a hostile letter to her sister, complaining about the qualities in her sister which she found objectionable in herself, namely, the aggression in seeking to be the center of attraction. She seemed to gain an intellectual understanding of her problem without any fundamental change of attitude.

In summary, this patient showed a personality organization which may be considered hysterical. She was a hostile, aggressive person of immature emotional development. Under the threat of blackmail, there developed hysterical aphonia. This conversion symptom appeared long after the signs of multiple sclerosis had become established.

It is also clear that the signs of multiple sclerosis were manifest at a critical period in this patient's emotional life. Her superiority was threatened by her husband's growing success and her own feeling of lack of achievement. She sought extramarital satisfactions as a way to prove that she was attractive and to humiliate her husband.

Case 3.—J. B., a married woman aged 29, was admitted to the Phipps Clinic on June 10, 1944, after the incision of a carbuncle in her right axilla, which had been treated in another hospital. She had felt guilty about taking a much needed bed from some one else after the head nurse said to her, "Any one who can walk to the bathroom is not sick enough to be in the hospital." She began to have a staggering gait, which the nurse considered a bid for further care. Later she became confused and had delusions of a paranoid nature.

On admission here, she was euphoric but would begin to cry without apparent reason. Her signature was shaky, and each word had an upward slant. She kept her eyes closed because her vision was blurred and she saw double. Neurologic examination revealed ptosis of the left lid, nystagmus, weakness of the left side of the face and slurring of speech. The finger to nose test showed

bilateral ataxia. The gait was unsteady, with a tendency to walk to the left. The Hoffmann reflex was present bilaterally. The abdominal reflexes were absent. The spinal fluid was normal. The mental symptoms and the signs of organic neurologic disease disappeared after a few days.

Five years earlier, during her third pregnancy, there was an episode of garbled speech, paresis of the left side of the body and diminution of vision toward the left for a few hours after a tense period in which she was cleaning the hall, a task which always made her irritable. Since that time any extremes of tension produced numbness of the extremities and garbling of speech momentarily. These attacks had been frequent just before hospitalization.

The patient left the hospital in twenty-one days because she felt well and did not see the need for any change of attitude. During this period of hospitalization she showed a great deal of hostility and resentment. She returned in May 1945, complaining of dizzy spells, in which she felt that she would fall backward. The edges of objects appeared blurred to her. Neurologic examination showed only slight and questionable abnormalities. She was extremely resentful of the attitude of her husband, who was immersed in business affairs and gave her little attention. She remained in the hospital for a little over two months to discuss her emotional problems.

The patient belonged to a family of superior economic status. Her father was a rigid, obsessive person, who insisted that everything should be in its place. Her mother had been an invalid since the patient was 10 years old and died three months after the patient's marriage. Indeed, her death was said by the family to be the result of this marriage, of which the mother strongly disapproved. The mother showed no real affection for her children. The patient was always frightened of her sister, 18 months older, who was described as selfish, impulsive and ambitious. The sister's son, aged 8, had had psychiatric treatment. The second sister of the patient, who was three years younger, had a schizophrenic-like illness after the death of her mother.

The patient grew up resentful of this family and always had difficulty in making social contacts. Her relatives referred to her as "plain." She did well in her studies and was taking a premedical course when she eloped, at the age of 20, with a man who "passed out from alcohol" the first time she met him. Both sides of the family opposed this marriage strongly. Her husband insisted that they live with his grandmother, who was a domineering old woman, with a house in the run-down portion of the city. The patient hoped to make up to this grandmother the wrongs she felt she had done to her own mother but became resentful instead. Later, her father married her mother-in-law, and the patient became hostile toward this woman.

Sexual adjustment was always poor, and the patient never experienced sexual satisfaction. She vomited through her two full term pregnancies. When she was pregnant for the second time, her mother-in-law, and stepmother, insisted on an abortion. It was during the third pregnancy that she first exhibited neurologic symptoms.

In the hospital, she showed a great deal of hostility toward the personnel and patients. She aired her annoyance toward all members of the family except her father. On one occasion she said that God would be like her father. She attempted to be accepted as a little girl, and was resentful when she was not accepted on this basis. She left the hospital with the belief that she could be more tolerant with other people. However, it was felt that there had been little significant change in her attitude.

In summary, this patient was dependent on approval and resented her need of it. She was immature physically, emotionally and psychosexually and felt hostile and resentful toward any one who did not treat her like a little girl. She was attached to her father and still played the part of a child in her relationship to him. Sexually she was poorly adjusted, and she felt ambivalent toward her husband. Symptoms developed when the home situation became unbearable. The patient showed a hysterical pattern of emotional adjustment. Clearcut signs of organic disease of the nervous system were observed on her first visit to the hospital.

CASE 4.—D. R., a married woman aged 27, was admitted to the Phipps Clinic because she was depressed. She was overwhelmed by a terrifying sense of fear and suicidal preoccupations. Two years earlier she suddenly lost vision in her right eye. She entered the Episcopal Eye, Ear and Throat Hospital, in Washington, D. C., where the diagnosis of optic neuritis was made. This blindness disappeared in a few weeks. A neurologist examined her, told her that she had multiple sclerosis and advised her to move to a warm climate. Her vision returned, and she did not take this advice. However, she read a good deal about the disease and looked for further symptoms. Whenever she became cold, she thought that her legs were becoming numb. She feared to go outdoors on a cold day.

There were few objective signs of multiple sclerosis when she entered this hospital. She showed labile emotional responses, with excessive crying and laughter. The optic disks were poorly outlined, and the right disk was flat and pale. The abdominal reflexes were absent.

The patient remained in the hospital for thirteen months. During this time she talked freely about her problems, revealed a rich fantasy life and presented many dreams. She was an intelligent, likeable person, with a good deal of creative ability. There was a tendency to be careless in dress and personal appearance.

She described herself as caught in a conflict between two cultural patterns. Her father, who was hospitalized here for a depression twenty-five years ago, was a native of a small island in Chesapeake Bay. The islanders are a clannish, interrelated group, with strict moral standards and intolerant of the attitudes of the outside world. The patient's mother came from the mainland and never accepted or was accepted by the inhabitants of the island. The patient had to move to the mainland at the age of 12 because there were no adequate schools on the island, and she lived away from the family from that time. She finished normal school at the age of 18 and taught school for three years, with little satisfaction.

At the age of 21 she married, largely because she wished to escape from school teaching. Her husband was an ineffectual person, who was postmaster in a small town and was unable to support the family adequately. They lived with his mother until after the birth of their 2 children. The patient, who was proud and ambitious, urged him to greater efforts. Finally, he obtained an evening job to supplement his income, and the patient was left without companionship.

Sexual adjustment had never been satisfactory. She had had two affairs before marriage and an abortion at the age of 18. She did not obtain sexual satisfaction with her husband because she was unable to relax.

The period of blindness developed at a time of great emotional stress. It occurred after the birth of her second child. She regretted the second pregnancy coming so soon after the first and doubted her ability to care for two children. The financial situation was unsatisfactory, and she felt lonely with her husband gone in the evening. She had always been timid and afraid of the dark.

During subsequent interviews, it became evident that she had identified at times with her father and at other times with her mother. As a child she had been frightened by her father's psychotic episode. She had fallen in love with a man who lived on the island but later rejected the possibility of marrying him. In general, she had patterned herself after her mother and had married a man who was somewhat like her father. "Mother decided most things for me." She resented her husband because he was a dreamer and they had so little in common. He had not satisfied her sexually or given her adequate companionship. She held him responsible for the second pregnancy. "I have never felt right since the second child was born." She had worried greatly about multiple sclerosis. She always feared that her legs would become involved and did not consider the possibility of symptoms in other portions of her body.

During the entire stay in the hospital the patient showed great lability of emotional responses, both of laughing and of crying. She was able to express her anxiety and resentment in relation to interpersonal relationships. Gradually her self assurance returned, and she left the hospital to resume care of her home.

In summary, the patient was an emotionally immature woman, who showed difficulties in sexual adjustment. From childhood she had had difficulty in relating herself to the different cultural ideals of her father and mother. She had become a proud, ambitious and capable woman, like her mother, and married an ineffectual man, like her father. The patient found herself unable to deal with the resentments which developed in this situation and became depressed. During the depressed period she showed great emotional lability, not only of crying but also of laughing.

The diagnosis of multiple sclerosis had been made two years earlier. During the period of hospitalization she showed only minimal abnormalities on neurologic examination, and no symptoms of the disease. Although there is no reason to doubt that the diagnosis was correct, it would not have been considered at the time when we saw her unless the previous history had been available.

CASE 5.—This patient was seen only once, for diagnostic study. M. I., a housewife, white, aged 36, complained of stiffness of her legs and her right arm. These symptoms had begun two and a half years prior to admission, after the birth of her second child. About a month after the child was born, the patient, while attempting to get out of bed one morning, found that her legs were extremely stiff, so that she was unable to move them. This stiffness tended to increase. Her right leg was awkard and tremulous. About six months prior to admission there was a period of blurring of vision.

Examination revealed that the patient was thin and apparently euphoric. The left optic disk was pale, and there was nystagmus on looking toward the left. The gait was spastic and somewhat ataxic, so that she had difficulty in walking and tended to fall. There was some awkwardness of the right arm on pronation and supination and in the finger to nose tests. The deep reflexes were all over-

active. There were Hoffmann and Babinski reflexes and ankle clonus bilaterally. The abdominal reflexes were absent.

The patient was the next to the youngest of 8 children, born to a family of low economic status. The mother suffered with her feet, which tended to itch and burn. This was attributed to frequent childbearing.

The patient was always well until the onset of her present illness. At the age of 24 she married and bore 2 children. She said that she never had any sexual interest and that sexual relations were always unpleasant to her. She and her husband had no sexual relations for some time after they were married. The older child was born with a great deal of difficulty, and the patient dreaded the second pregnancy. She used to worry a great deal about the first child, fearing that something was going to happen to him. Since the onset of her present illness, she said that she had not worried at all.

The patient tended as far as possible to minimize her symptoms. She denied that she had any trouble with her eyes, whereas a letter from a previous physician described blurring of vision. She said, "I don't want to remember. I try to forget unless you pin me down. I am trying to help myself." She said that she noticed that when she was excited she could not walk well. Before her illness began, she was particular about her work. "I always want to do things fast and just right. I always had my work done before noon."

In summary, this patient showed evidence of emotional immaturity, which was evident in the psychosexual adjustment. She felt inadequate to care for her children, and the symptoms developed soon after the birth of her first child. She had a wish to forget her symptoms and recalled them with some difficulty.

PRESENT ETIOLOGIC THEORIES OF MULTIPLE SCLEROSIS

The factors which lead to the development of multiple sclerosis have never been sharply defined. There are two main schools of thought with regard to its cause. On the one hand, it is considered as an infectious disease; on the other, as a noninfectious process. There is no positive evidence of infection, although at times bacteria, spirochetes and filtrable viruses have been thought to be implicated. The studies of the past few years have approached the problem on a noninfectious basis.

Putnam[2] (1936) made a significant advance by showing that the characteristic perivascular demyelination may be produced experimentally in a number of ways. However, according to Putnam, all these experimentally produced demyelinated areas are dependent primarily on thrombosis of small blood vessels on the venous side of the capillary bed. Any method of approach which will cause a closure of these vessels will produce characteristic demyelination.

Another fruitful field for experimental work has been a consideration of demyelinating diseases as caused by allergic reactions in the brain. Thus, Rivers, Sprunt and Berry[3]; Rivers and Schwentker,[4]

2. Putnam, T. J.: Studies in Multiple Sclerosis: VIII. Etiologic Factors in Multiple Sclerosis, Ann. Int. Med. **9**:854-863, 1936.

(Footnotes continued on next page)

and Ferraro,[5] by means of experimentally produced allergic responses, obtained areas of demyelination in the brain of monkeys and other animals which had all the characteristics of the areas of demyelination seen in multiple sclerosis.

If the theory advanced by Putnam is correct, disturbances of circulation may account for the localized areas of loss of myelin. Conceivably, the disturbances of blood flow in the small veins of the brain may be brought about in many ways and by many types of abnormalities. This would serve to unify the various points of view concerning the nature of the disease and to focus attention on factors which produce disturbances of circulation.

From the clinical point of view, multiple sclerosis may be considered as a syndrome which is loosely knit together. Some cases are characterized by periods of remission during the early periods of the disease, while in others there is no remission. The patient may show rapid progress of the syndromes and die within a matter of months. In a larger group the general length of life expectancy is not much less than the average.

Putnam,[2] Ferraro [5] and others pointed out the pathologic analogy between multiple sclerosis and the various types of postinfectious encephalomyelitis. The primary demyelinating diseases include disseminated encephalomyelitis, Schilder's disease, diffuse sclerosis and neuromyelitis optica. The histopathology of these disorders is fundamentally uniform, the difference being in the location and intensity of the lesions.

Putnam, McKenna and Morrison [6] considered the acute diseases of the nervous system characterized by areas of demyelination (usually perivascular) with relative preservation of axis-cylinders and infiltration with round and glial cells. This group of diseases has been called by various names, such as acute multiple sclerosis, acute disseminated encephalomyelitis and degenerative encephalopathy. The condition may follow acute infections, especially vaccinia and measles. Putnam [2] pointed out that postinfectious encephalitis and multiple sclerosis may represent the same pathologic process at different stages, with variations in intensity. He stated that anoxemia, or, more specifically, local venous

3. Rivers, T. M.; Sprunt, D. H., and Berry, G. P.: Observations on Attempts to Produce Acute Disseminated Encephalomyelitis in Monkeys, J. Exper. Med. **58**:39-53, 1933.

4. Rivers, T. M., and Schwentker, F. F.: Encephalomyelitis Accompanied by Myelin Destruction Experimentally Produced in Monkeys, J. Exper. Med. **61**: 689-702, 1935.

5. Ferraro, A.: Pathology of Demyelinating Diseases as an Allergic Reaction of the Brain, Arch. Neurol. & Psychiat. **52**:443-483 (Dec.) 1944.

6. Putnam, T. J.; McKenna, J. B., and Morrison, L. R.: Studies in Multiple Sclerosis: I. The Histogenesis of Experimental Sclerotic Plaques and Their Relation to Multiple Sclerosis, J. A. M. A. **97**:1591-1595 (Nov. 28) 1931.

obstruction, should receive consideration as the immediate cause of the primary demyelination.

He observed that myelin is more easily damaged than the axis-cylinder as a result of insufficient blood supply. Regeneration of completely destroyed myelin does not occur in the central nervous system of adult animals even when the axis-cylinder is intact. Whenever myelin is destroyed, there is a proliferation of fixed glial cells.

Although many articles on multiple sclerosis stress the importance of emotional disturbances in causing an increase in symptoms, there is little specific information in the literature. Nor has there been any speculation concerning the manner in which emotional turmoil influences organic symptoms. It seems important, therefore, to summarize the information obtained from the patients described here and to attempt to understand something of the relation of their personal problems to the symptoms of multiple sclerosis.

COMMENT

The patients described in this report show rather strong similarities in their emotional reactions and their attitudes toward significant persons in their lives. It is in a way unfortunate that all the patients were women. However, in male patients with multiple sclerosis it is quite clear that there is often marked immaturity in the emotional sphere. Discussion will be confined largely to the first 4 patients, who were studied in greater detail.

All the 4 patients were caught up in some entangling neurotic relationship with one of the parents. At first, one might assume that it was not the same parent in all cases. There is, however, some evidence that it was always the mother. The first patient said that she was like her mother but as a child identified with her father. She tended to reject many of the ideals which her mother represented but saw many of the same traits in herself. Her relation to her father had been fairly satisfactory to her. The maternal relationship was the complicating one. The second patient patterned her life after her mother but found this role an unsatisfactory one. At first she was resentful toward her father, whom she considered a weak person. Later, she reversed her opinion and came to admire her father. At the same time she rejected her mother's attitudes. The third patient never had any satisfactory relationship with her mother. She identified with her father. The fourth patient was caught in a neurotic relationship with both her parents. It is clear that her mother was the dominating personality, with whom she was most entangled. Indeed, the first patient fled from her parents and husband to avoid all the close relationships, which had been so unsatisfactory.

The emotional immaturity made sexual relationships unsatisfactory. The first patient always found sexual relationships unpleasant and pain-

ful. She had never wanted children. The second patient had promiscuous sexual relationships, in the hope of obtaining greater satisfaction and in order to humiliate her husband. The third patient never experienced any sexual satisfaction. The fourth patient was frigid sexually.

All these 4 women were married, and the story of their selection of a husband shows a notable similarity. They married, in defiance of their parents' wishes, men whom they considered intellectually and socially inferior to themselves. They hoped in this way to escape from their passive role and take part in some relationship in which they could dominate. Thus, the first patient married a man whom she considered her social and intellectual inferior. The second patient, who was a school teacher, married a man whom she picked up on a street corner. The third patient, who was planning to study medicine, married a man who passed out from alcohol the first time that she met him. This marriage was violently opposed by her family. The fourth patient married a timid, ineffectual man.

There is also some evidence that these patients became ill at a time when their husbands gained more self assurance and began to assume a more dominant role. The first patient tried to help her husband to a better business position. Finally, against her advice, he started a business of his own and began to prosper without her help. At this time her symptoms increased and she decided to leave him. The second patient became ill at the time when her husband exceeded her in earning power. At the same time she began to have extramarital affairs in an attempt to humiliate him. The third patient bitterly resented her husband's increasing prosperity on the grounds that he gave her less attention. The husband of the fourth patient took a second job in order to support the family more adequately. This was an issue at the time when the patient became sick.

Pregnancy was a factor in the illness of several of these patients. The second patient showed a pronounced accentuation of the symptoms after a therapeutic abortion. She was extremely resentful toward the physicians who advised the abortion. Pregnancy was a great issue with the third patient. She vomited throughout gestation. The second pregnancy was aborted at the insistence of her family. It was during the third pregnancy that she exhibited the first symptoms of multiple sclerosis. The period of blindness experienced by the fourth patient occurred just after the birth of the second child. She did not wish another child so soon and felt inadequate to care for the two children. The fifth patient had worried a great deal about her first child and dreaded the second pregnancy. Her symptoms began a month after the second child was born.

It has long been recognized that the symptoms of multiple sclerosis may begin with, or be accentuated during, pregnancy or in the weeks

following the birth of the child. This has been attributed to the strain of pregnancy on the body. Another explanation might stress the emotional reaction of the patient to the pregnancy. In each of the cases presented here the patient felt insecure and resentful concerning the pregnancy.

It is perhaps important to mention that in this report the term hysteria is applied strictly to conversion hysteria. Two of the patients reported on here showed rather clear signs of conversion hysteria. The manifestations in these patients appeared after the signs of multiple sclerosis were well established. The second patient showed a hysterical aphonia as a reaction to a difficult situation. The fifth patient thrust certain details of her illness out of her memory. In other of the patients the early symptoms of organic disease might have been considered hysterical if later evidence of organic disease had not clarified the situation. Thus, the first patient had several periods of blindness over a period of years. She recovered from each one, to feel quite well again. The fourth patient also had a period of blindness. During the time when she was observed in this clinic, she showed few signs of organic illness. The fifth patient gave a dramatic story of her legs giving way when she got out of bed one morning. However, organic signs were present from the beginning of her illness.

In making the diagnosis of hysteria the physician often feels insecure, fearing that later signs of organic changes in the nervous system will merit the diagnosis of multiple sclerosis. The diagnosis of hysteria should rest not only on the presence of conversion symptoms but also on an underlying hysterical personality. If this is present, the diagnosis of hysteria will still hold, even if there are, in addition, evidences of organic disease. The hysterical personality is essentially one which is emotionally immature. The emotional immaturity precludes normal satisfactory sexual adjustment. Indeed, it appears that these patients are undifferentiated in their definition of a sexual role. They remain extremely passive persons, but resent the passivity and show a wish to aggressive domination. In the present cases, there was an attempt in marriage to achieve domination over their husbands, and they sought marital partners whom they considered more passive than themselves. Difficulties arose in each case when the husband showed some evidence of self assertion.

In the cases which have been described the patients showed evidence of emotional immaturity and hysterical personality in addition to the signs of organic disease of the nervous system. The fourth case is perhaps the most interesting, in that the emotional factors held the center of the field and the organic changes might easily have been overlooked or disregarded. In the second patient, also, the organic signs were fleeting.

Several patients showed other types of abnormal emotional adjustment. They supplement our previous report of psychosis developing in patients with multiple sclerosis (Langworthy, Kolb and Androp [1]). Thus, the third patient showed paranoid symptoms when she came to the clinic. The second patient exhibited evidences of depression. The fourth patient had a severe depressive reaction, which was somewhat unusual because of the lability of emotional response in the direction of both laughing and crying.

In considering the relation between hysteria and multiple sclerosis in these patients, one must consider the possibility that conversion hysterical symptoms may "jell" into organic changes characteristic of multiple sclerosis. This type of formulation brings multiple sclerosis into the psychosomatic field and permits further speculation concerning the mechanism which induces the organic changes in the nervous system.

I wish it clearly understood that I am not formulating a theory which I feel will apply to all cases of multiple sclerosis. This disease can at present be thought of as a syndrome, rather than as a sharply defined entity. Since so little is known about the etiology, it is important to explore the problem from every point of view. It has always been realized that one facet of the disease touches the emotional problems of the personality. This merits further consideration, and a larger group of patients of both sexes should be studied exhaustively to determine their fundamental personality structure and their reactions to the disease.

THERAPY

A word may be said about treatment from the standpoint of psychotherapy. It might be said that this is the only possible approach to the problem of treatment which is available at the present time. Neurologists agree that the changes in the nervous system which have been established for some time tend to become irreversible and are not influenced by any type of treatment. The hope of therapy is to influence recently acquired abnormalities and prevent the development of further symptoms.

These patients usually show a great need for a physician to interest himself in their problem. They tend to relate themselves to him in the same passive and childish emotional pattern which they have shown toward the other significant people in their lives. The physician's problem is to challenge this attitude on the part of the patient and endeavor to help the patient toward a more mature and satisfactory relationship. Psychiatrists have often felt that hysteria was a rather benign type of emotional difficulty which yielded fairly easily to psychotherapy. Undoubtedly, it is possible to dispel one conversion symptom, but the problem of helping the patient to achieve further emotional growth presents grave difficulties. These patients tended to acquire

some insight at a verbal level without any notable indication of growth in emotional maturity.

The first patient was the only one whom I followed personally through the period of treatment. She was not hospitalized and had the opportunity of continually working out her adjustments in a home situation. Her symptoms and physical abnormalities were not firmly established but had shown exacerbation and remission over a long period of years. In her better periods she was scarcely handicapped by the physical symptoms. This was an ideal case for treatment. It was my feeling that she clarified her attitudes and planned a reasonable course for herself along lines which would allow her further self assertion and permit further growth of her personality. After she had an opportunity to review the situation and set her course along lines which seemed to offer satisfaction to her, her symptoms became less prominent.

Physicians often fail to realize that certain patients with this disease live a fairly comfortable life for many years. Thus, I still have under observation a man who had severe paraplegia in 1928 and has shown symptoms periodically since that time. At present he is married, works regularly and is able to support his family. On the other hand, he shows minor physical handicaps. He has received the interested attention of his physician over a period of years, which in itself may be classed as psychotherapy.

SUMMARY

A number of patients with multiple sclerosis show signs of conversion hysteria either before or after the development of signs of organic disease. The 4 women whose cases are described in detail showed evidence of emotional immaturity at a preadolescent level. They were caught in an entangling neurotic relationship with the mother. There was a tendency to relate themselves to others in a passive way, which led to resentment and hostility. In choosing a husband, they sought a passive person whom they thought intellectually and socially inferior to themselves, in an apparent attempt to assume a dominating role. Sexual relations were never satisfactory. They showed the appearance or accentuation of organic symptoms at a time when the husband became more self assertive and capable.

These patients showed pronounced evidences of vasomotor instability in the extremities. The question arises whether vascular changes in the brain related to the neurotic difficulties could lead, in turn, to organic changes. Since the cause of multiple sclerosis has not been established, it can be thought of as a syndrome, and the data presented here do not necessarily apply in all cases. Psychotherapy offers as hopeful an approach as any other treatment which is now available, and may present one method of understanding these patients better.

Henry Phipps Psychiatric Clinic.

HEMOCONCENTRATION AFTER ELECTRICALLY INDUCED CONVULSIONS IN MAN

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AND

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CONCENTRATION of the blood and decrease in plasma volume are known to develop during exercise.[1] In view of the fact that variations in water balance influence the activity of the cerebral cortex [2] and may also give rise to important changes in the body as a whole, it was considered desirable to investigate the occurrence of hemoconcentration during the violent muscular contractions of electrically induced convulsions.

MATERIAL AND METHODS

Fifty-five studies of hematocrit readings and 60 determinations of plasma protein were made before and after routine electroshock treatments on 10 patients. Six of the patients were men, and the range in age for all patients was 25 to 61 years; several had had previous shock therapy. In addition, 1 patient (case 11), a woman aged 59, was studied on 5 occasions on which convulsions were induced after she had received 42 units of curare ("intocostrin") intravenously.

Samples of blood were drawn without stasis from an antecubital vein immediately before shock, as soon as possible after the convulsion and again either fifteen or thirty minutes after shock. Plasma protein was estimated from the specific gravity of the plasma as measured by the Van Slyke copper sulfate method [3]; the oxalate mixture recommended for this procedure was used as an anticoagulant. An attempt was also made to measure hemoglobin concentration by the same method, but the copper proteinate sac failed to form satisfactorily

From the Clinical Services, McLean Hospital, Waverley, Mass., and the Medical Research Laboratories, Beth Israel Hospital, and the Departments of Psychiatry and Medicine, Harvard Medical School, Boston.

1. Kaltreider, N. L., and Meneely, G. R.: The Effect of Exercise on the Volume of the Blood, J. Clin. Investigation **19**:627, 1940.

2. McQuarrie, I.; Anderson, J. A., and Ziegler, M. R.: Observations on the Antagonistic Effects of Posterior Pituitary and Cortico-Adrenal Hormones in the Epileptic Subject, J. Clin. Endocrinol. **2**:406, 1942.

3. Phillips, R. A.; Van Slyke, D. D.; Dole, V. P.; Emerson, K., Jr.; Hamilton, P. B., and Archibald, R. M.: Copper Sulphate Method for Measuring Specific Gravities of Whole Blood and Plasma, Bull. U. S. Army M. Dept., December 1943, no. 71, p. 66.

around the drop of blood, possibly as a consequence of increase in the amino acid of the blood during the convulsion.[4] In 5 determinations, including 1 of the studies with curare, changes in plasma volume were measured by means of the technic of Gibson and Evans,[5] using their indirect method.

OBSERVATIONS

The initial hematocrit values were normal in every case, ranging from 41 to 55 per cent of cells. Of the 55 observations on patients

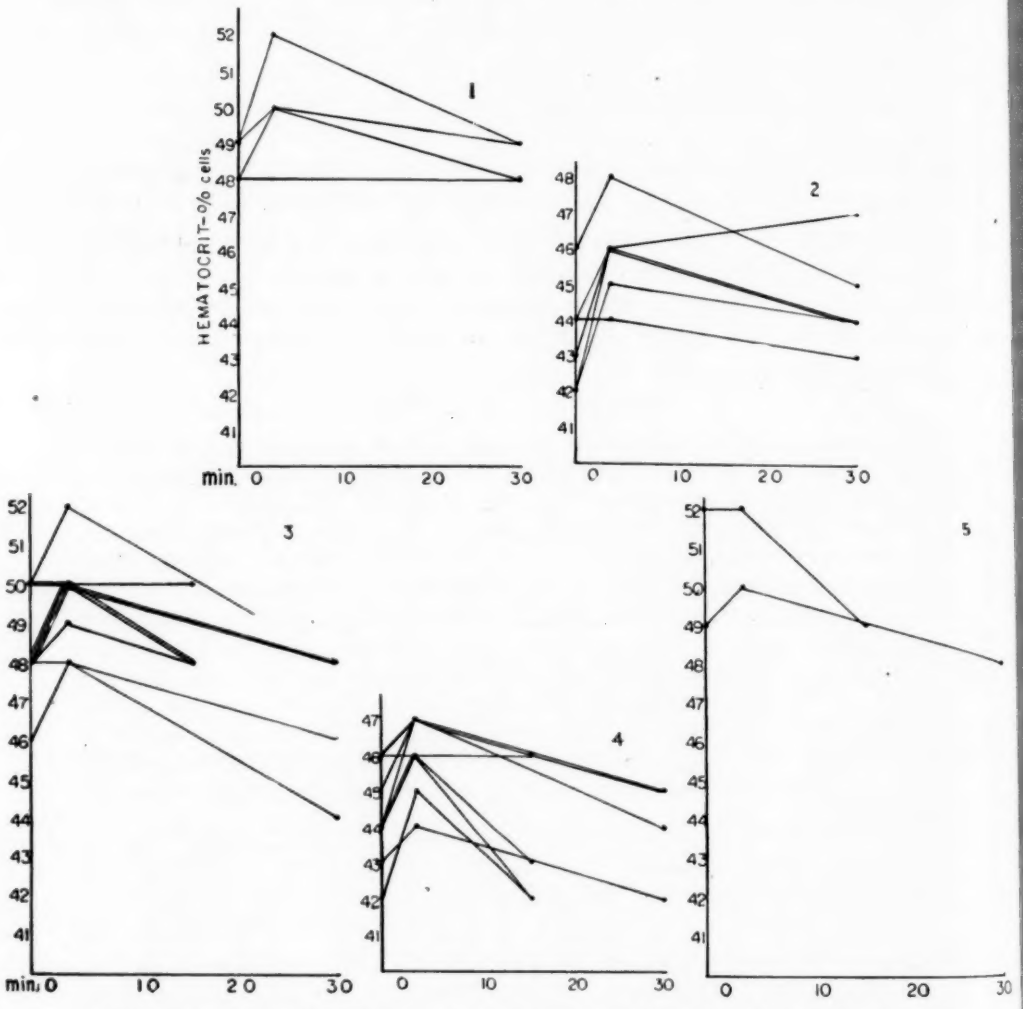
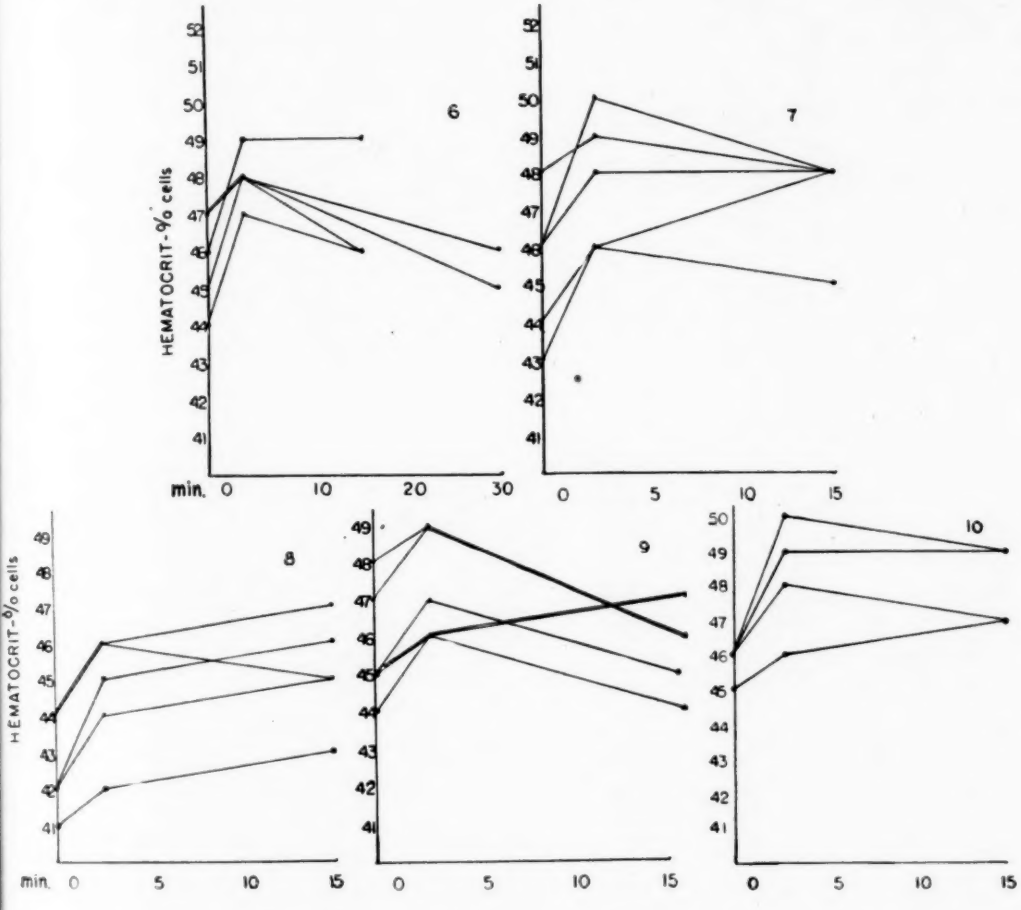


Fig. 1 (cases 1-10).—Changes in hematocrit reading after electrically induced convulsions.

4. Quigey, J. J., and Muraschi T. F.: Amino Acid Inhibition of Copper Proteinate Formation, J. Biol. Chem. **158**:467, 1945.

5. Gibson, J. G., II, and Evans, W. A., Jr.: Clinical Studies of the Blood: I. Clinical Application of a Method Employing the Azo Dye "Evans Blue" and the Spectrophotometer, J. Clin. Investigation **16**:301, 1937.

studied without curare the hematocrit value immediately after the cessation of the convulsions was increased in all but 7, in which no change occurred (fig. 1, *1-10*). The increase ranged from 2.1 to 9.5 per cent of cells. The average increase for each determination was from 1.2 to 5.4 per cent of the control values, and the average increase for all determinations, 3.9 per cent of the average control value. Subsequent changes during the fifteen or thirty minutes following the convulsion varied



considerably; however, in most instances a decrease toward, or occasionally below, the control levels occurred.

The initial plasma protein levels ranged from 5.37 to 7.62 Gm. per hundred cubic centimeters. Of the 60 observations made in studies without curare the values at the end of the convulsion had increased in all but 2, in which decreases of 0.28 Gm. occurred (fig. 2, *1-10*). The increases in the 58 other observations ranged from 0.21 to 1.46 Gm., or from 5.0 to 12.5 per cent of the control values. The average for all changes in plasma protein at the end of the convulsion, exclusive of

those for the curarized patients, was + 0.63 Gm., or + 9.8 per cent. Subsequent changes during the fifteen or thirty minutes following the convulsion varied; in most instances a decrease toward, or at times below, the control levels occurred.

In the 4 cases shown in the table in which studies were made without curare, the plasma volume, initially within the normal range, decreased by 200 to 1,040 cc., or 9 to 35 per cent of the control values.

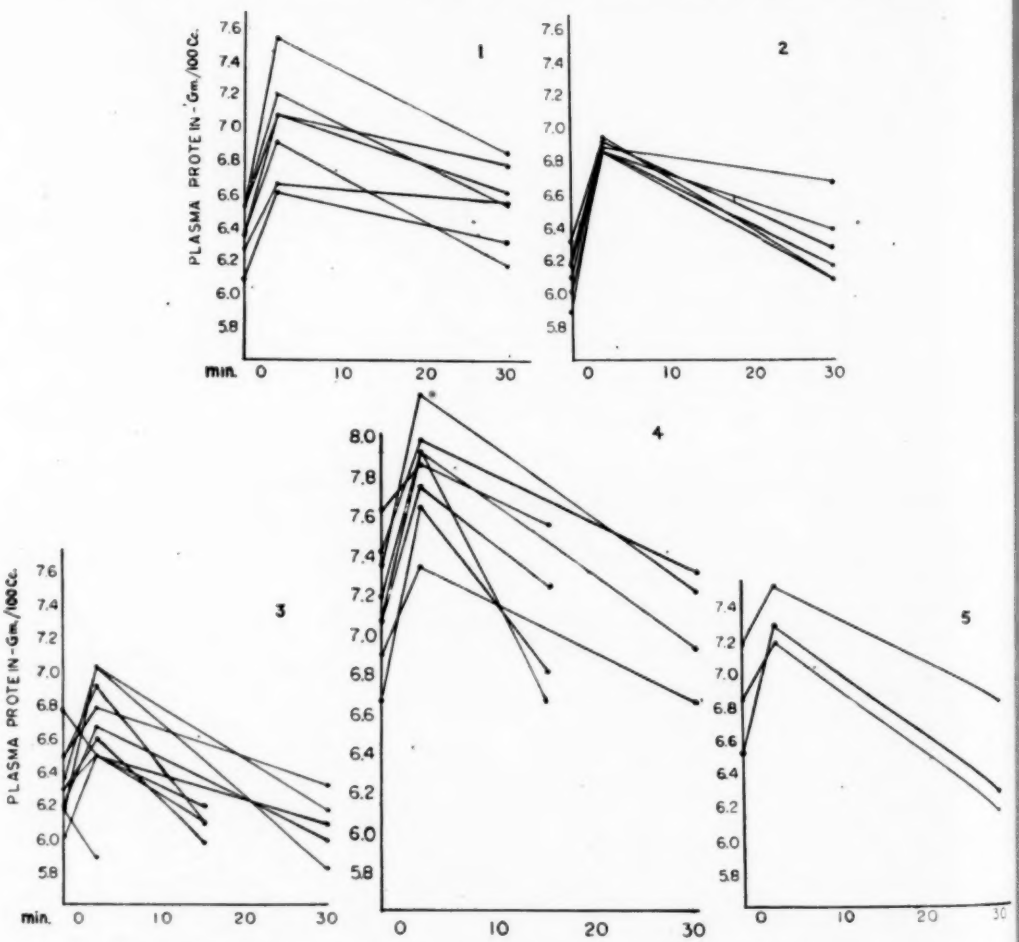
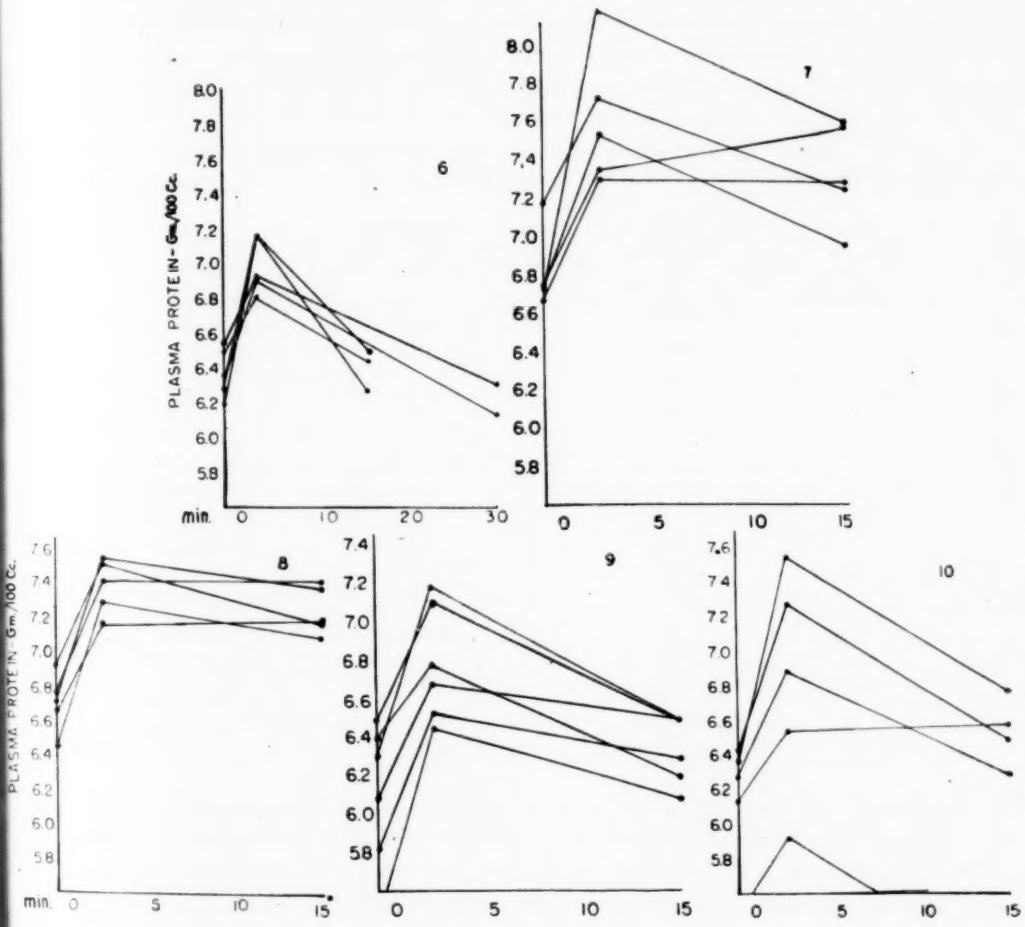


Fig. 2 (cases 1-10).—Changes in plasma protein level after electrically induced convulsions.

The average decrease was 560 cc., or 18 per cent (table). Fifteen minutes after the seizure increases toward the control level occurred in 3 of the 4 cases. The changes varied in degree with increases in plasma protein. No change in the calculated total circulating protein occurred in 3 of the 4 cases; in the fourth a significant decrease was noted.

Effect of Curare.—In 2 of 4 studies of the hematocrit reading on the patient whose convulsions were modified by means of curare, no change was found after the seizure; in the other 2 studies increases of 2.5 and 7.3 per cent above the control values occurred (fig. 3). The initial values were normal, ranging from 40 to 48 per cent of cells. The initial values for plasma protein in this patient were also normal; they ranged from 5.47 to 6.65 Gm. per hundred cubic centimeters. In



5 studies on this patient, increases of 0.17 to 0.77 Gm. per hundred cubic centimeters, or 3.1 to 13.8 per cent of the control value, were found at the end of the convulsion (fig. 4). The average increase was 0.41 Gm., or 6.8 per cent. The plasma volume was studied for this patient only on the occasion of the least change in plasma protein concentration after the convulsion; no change in plasma volume was found at this time (table).

COMMENT

The data of the present study demonstrate the occurrence of transitory hemoconcentration during electrically induced convulsions, as suggested by earlier fragmentary observations of Centini and Bandettini di Poggio.[6] The extent of this hemoconcentration cannot, however, be determined with precision with the methods used here. While it is unlikely that errors occur because of the addition of red blood cells to the circulation, judging from the observations of Kaltreider and Meneely [1] after ordinary exertion, studies based on changes in hematocrit readings alone are not reliable. The hematocrit value is not uniform throughout the body,[7] and since the convulsive seizure gives rise to sudden pro-

Effects of Convulsion on Plasma Volume and Plasma Protein

Case No.	Sex	Plasma Volume, Cc.	Plasma Protein, Gm./100 Cc.	Total Circulating Protein, Gm./100 Cc.	Comment
6	F	2,140	6.27	134	Before treatment
		1,940	7.16	139	1 min. after treatment
		2,210	6.49	143	15 min. after treatment
7	M	3,000	6.86	206	Before treatment
		1,960	8.17	160	1 min. after treatment
		2,740	7.53	206	15 min. after treatment
8	M	3,130	6.69	209	Before treatment
		2,610	7.29	190	1 min. after treatment
		2,900	7.08	205	15 min. after treatment
9	M	3,910	5.45	213	Before treatment
		3,430	6.44	221	1 min. after treatment
		3,430	6.06	208	15 min. after treatment
11	F	3,010	5.37	162	Before treatment
		2,960	5.64	167	1 min. after treatment
					Received 42 units intocostrin before shock
		2,910	5.73	167	15 min. after treatment

nounced circulatory changes, it is apparent that the hematocrit value cannot be relied on to indicate any more than directional changes in blood volume. In addition, rapid changes in the carbon dioxide content of the blood during and after the convulsions [8] probably give rise to

6. Centini, D., and Bandettini di Poggio, A.: Ricerche biochemiche in schizofrenici durante l'elettroshock, Rassegna di studi psichiat. **28**:875, 1939.

7. Ebert, R. V., and Stead, E. A., Jr.: Demonstration That the Cell-Plasma Ratio of Blood Contained in Minute Vessels Is Lower Than That of Venous Blood, J. Clin. Investigation **20**:317, 1941.

8. Altschule, M. D.; Sulzbach, W. M., and Tillotson, K. J.: Effects of Electrically Induced Convulsions upon Respiration in Man, Am. J. Psychiat. **103**:680 (March) 1947.

variable degrees of swelling of the erythrocytes.[9] The plasma protein level is probably uniform throughout the body, but its accuracy as an indicator of the degree of hemoconcentration is vitiated to some extent by the fact that protein may be lost through the capillary wall when filtering pressures are greatly elevated.[10] Similarly, measurements of changes in plasma volume in these circumstances are also somewhat inaccurate, since the dye used becomes attached to plasma protein after injection.[11] However, changes found in plasma protein level and in concentration of the circulating dye in a study such as the present one minimize, rather than exaggerate, the amount of hemoconcentration which occurs. Decreases in total circulating protein cannot be detected here unless globulin is lost, an unlikely event except when filtering pressures are extremely high.

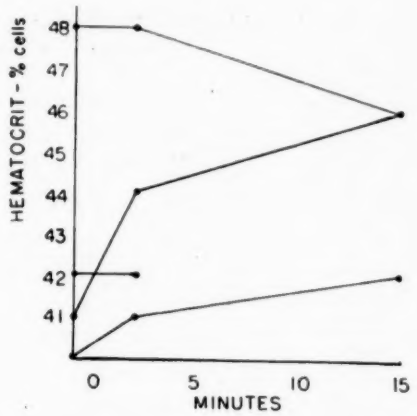


Fig 3 (case 11).—Changes in hematocrit reading after electrically induced convulsions in a curarized patient.

During electric shock there is a sharp transitory rise in the venous pressure, often to levels higher than 80 cm. of water.[12] Increases in

9. Dacie, J. V.; Lond, M. B.; Vaughan, J. M., and Oxon, D. M.: The Fragility of the Red Blood Cells: Its Measurement and Significance, J. Path. & Bact. **46**:341, 1938.

10. Landis, E. M.; Jonas, J.; Angevine, M., and Erb, W.: The Passage of Fluid and Protein Through the Human Capillary Wall During Venous Congestion, J. Clin. Investigation **11**:717, 1932.

11. Gregersen, M. I., and Gibson, J. G.: Conditions Affecting the Absorption Spectra of Vital Dyes in Plasma, Am. J. Physiol. **120**:494, 1937.

12. (*a*) Silfverskiöld, B. P., and Åmark, C.: Disturbances of Circulation in Convulsions of the Epileptic Type: II. Arterial and Venous Pressure During Electroshock, Acta med. Scandinav. **113**:191, 1943. (*b*) Altschule, M. D.; Sulzbach, W. M., and Tillotson, K. J.: Changes in Peripheral Venous Pressure During and After Electrically Induced Convulsions in Man, Arch. Neurol. & Psychiat., to be published.

venous pressure cause loss of fluid from the circulation into the tissues [13]; at pressures as low as 17 cm. of water, fluid will accumulate in the tissues, and at higher pressures the transudation is considerable and rapid.[13d] It is likely that the observed changes in venous pressures [12] are at least largely responsible for the hemoconcentration which is found after exertion [1] and, as in the present study, after convulsions. It is to be noted that the patient in whom convulsions were induced after curarization exhibited only a slight rise in venous pressure [14] and a lessened amount of hemoconcentration during her seizures.

Another factor which possibly may favor loss of fluid from the circulation is anoxia, for it has been shown that anoxia occurs during electrically induced convulsions.[8] Landis [15] found that in animals there is a fourfold increase in the rate at which fluid moves through a capil-

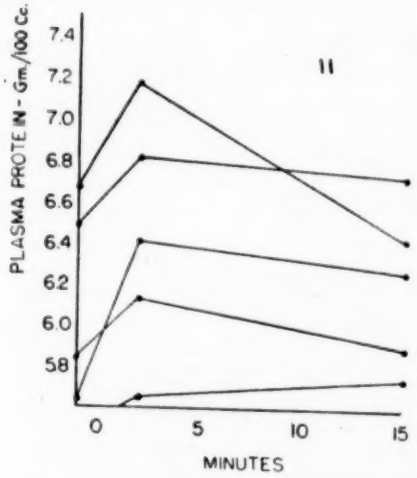


Fig. 4 (case 11).—Changes in plasma protein level after electrically induced convulsions in a curarized patient.

13. (*a*) Landis and others.[10] (*b*) Drury, A. N., and Jones, N. W.: Observations upon the Rate at Which Oedema Forms When the Veins of the Human Limb Are Congested, Heart **14**:55, 1927. (*c*) Landis, E. M.: Micro-Injection Studies of Capillary Permeability: II. The Relation Between Capillary Pressure and the Rate at Which Fluid Passes Through the Walls of Single Capillaries, Am. J. Physiol. **82**:217, 1927. (*d*) Krogh, A.; Landis, E. M., and Turner, A. H.: The Movement of Fluid Through the Human Capillary Wall in Relation to Venous Pressure and to the Colloid Osmotic Pressure of the Blood, J. Clin. Investigation **11**:63, 1932. (*e*) Landis, E. M., and Gibbon, J. H., Jr.: The Effects of Temperature and of Tissue Pressure on the Movement of Fluid Through the Human Capillary Wall, ibid. **12**:105, 1933.

14. Altschule, M. D., and Tillotson, K. J.: Modification By Means of Curare of the Circulatory Changes Occurring During Electrically Induced Convulsions, Arch. Neurol. & Psychiat., to be published.

lary wall rendered permeable to protein by anoxia. It is doubtful, however, whether the results of Landis'[15] experiments, in which oxygen was completely excluded, can be extended to the present study, in which complete anoxia did not occur. During electrically induced convulsions the oxygen of arterial blood decreases by one half or one third[8] and, although the oxygen of the antecubital or femoral venous blood may fall as low as 2 volumes per cent, the average oxygen level of tissues is more accurately represented by that of arterial blood, which, in the absence of respiration, is also the level of mixed venous blood.

The significance of the observations in the present study cannot be stated with certainty. The decreases in plasma volume here observed are probably important in explaining the fall in venous[12] and in arterial[16] pressures noted toward the end of electrically induced seizures in many patients.

It has been suggested by Pickford[17] that changes occurring in the water balance of tissues and blood influence the release or retention of the antidiuretic hormone; hemoconcentration apparently is one of the factors in the mechanism causing the production and release into the blood stream of this hormone. The hemoconcentration observed in the present study may possibly be important in explaining the rapid gain in weight which patients often show during the course of electric shock therapy; a few studies[18] by means of the thiocyanate method[19] indicate that much or most of the gain in weight is a consequence of an increase in extracellular fluid volume. It is pertinent that voluntary muscular effort which causes hemoconcentration[1] also gives rise to liberation of antidiuretic hormone and transitory retention of water.[17] The question arises whether the brief periods of muscular contraction occurring during electrically induced convulsions can cause the same type of response of the pituitary gland as the more protracted voluntary muscular effort used in the reported studies on the antidiuretic hormone. It is worthy of note that in the studies based on protracted exercise, antidiuretic hormone was liberated in detectable amounts only during a brief initial period of the exertion.[17] The data of the present study

15. Landis, E. M.: Micro-Injection Studies of Capillary Permeability: III. The Effects of Lack of Oxygen on the Permeability of the Capillary Wall to Fluid and to the Plasma Proteins, Am. J. Physiol. **83**:528, 1928.

16. Cleckley, H.; Hamilton, W. F.; Woodbury, R. A., and Volpitto, P. P.: Blood Pressure Studies in Patients Undergoing Convulsive Therapy, South. M. J. **35**:375, 1942. Silfverskiöld and Åmark.[12a]

17. Pickford, M.: Control of the Secretion and Antidiuretic Hormone from the Pars Nervosa of the Ptiuitary Gland, Physiol. Rev. **25**:573, 1945.

18. Altschule, M. D.: Unpublished data.

19. Lavietes, P. H.; Bourdillon, J., and Klinghofer, K. A.: Volume of Extracellular Fluids of Body, J. Clin. Investigation **15**:261, 1936.

are no more than suggestive in regard to activation of the function of the posterior lobe of the pituitary as a consequence of changes in the blood during electrically induced convulsions. Definite conclusions must wait on further work, including an attempt to evaluate the role of the passage through the brain of the electric current itself, with direct stimulation of the hypothalamic-hypophysial mechanisms.

The therapeutic significance of the changes observed in the present study is unknown.

SUMMARY AND CONCLUSIONS

Studies of hematocrit readings, plasma protein concentration and plasma volume were made before and after electrically induced convulsions. Hemoconcentration and decreased plasma volume occur regularly. Curare diminishes, but does not abolish, these changes. The possible significance of the changes observed is discussed.

McLean Hospital.

SPATIAL ORGANIZATION OF VISUAL PERCEPTION FOLLOWING INJURY TO THE BRAIN

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AND
H. L. TEUBER, Ph.D.
NEW YORK

(Concluded from Page 739)

IN THE case reported in the preceding section, a persistent and systematic alteration in visual space perception was described in a case in which (consequent to a shrapnel injury of the posterior portion of the right parietal lobe) hemiparesis had developed but practically normal fields of vision were observed on standard perimetric examination. In the following case, an almost identical disorder in the perception of spatial relations was observed in a patient with shrapnel injuries of the occipital lobe. In contrast to the first case, the injury resulted in demonstrable homonymous field defects, but was not accompanied with any further changes in sensory or motor function.

CASE 2.—J. H. M., a radio man, third class, aged 20, was injured on Dec. 13, 1944 in the Philippine area, when a Japanese suicide plane hit his ship and exploded. He sustained multiple shrapnel wounds and lacerations of the head and body. He was given emergency treatment and was evacuated aboard a hospital ship. His head wound was examined, and some of the fragments of shrapnel were surgically removed from the posterior part of the brain on the right.

The patient's chief complaints after this operation were persistent tinnitus aurium (more intense on the right) and impaired vision. For one week he stayed aboard the hospital ship. When visited by his shipmates, he was able to recognize their faces, although they looked "funny." He specified this by saying that they seemed "so far away, but not really small." He made frequent attempts to describe this "funny" vision to his attendants but was unsuccessful.

Two weeks after the injury, when he began to feed himself, he noticed that he missed objects for which he reached. He claimed that he overshot his mark, but he was uncertain whether this occurred in all directions. Later he noticed that the glare of sunlight was extremely bothersome and increased his visual difficulties. In walking about, he frequently got the impression that people were standing on his left, but on turning his eyes he would convince himself that they were not really there. In descending a flight of stairs, the steps would flutter in his left field of vision and dizziness ensue.

When he arrived in the United States, one month after his injury, he still complained that his vision was blurred and strange. He still tended to bump into people on his left side. There was little improvement during the following months. During that period he became aware of the fact that his visual difficulties were primarily on his left side and was convinced that his left eye "was bad," his right

eye having become "practically normal." At times, however, objects directly before him appeared to recede slowly into the background, but within a few moments they reappeared in their former position. The latter phenomenon occurred especially when he blinked his eyes. In low illumination or semidarkness all his visual difficulties were increased.

In addition to these specific symptoms, the patient was tremulous and had nightmares in which he relived his battle experiences. With his persistence in relating details of his strange visual disturbance, he was considered by some physicians

Fig. 5.—Roentgenograms of the skull, showing location of the shrapnel. The trephine hole is seen in the right lateral view. In the anteroposterior view the defect in the skull produced by the shrapnel is apparent in the right occiptal region.

to be psychoneurotic. However, roentgenographic examinations of the skull showed signs of injury in the occipital lobe and the posterior part of the parietal lobe (fig 5). Besides the trephine hole in the posterosuperior portion of the right parietal bone, the films showed an irregular bony defect, about 1 cm. in diameter, in the right posterolateral portion of the occipital bone. Stereoscopic roentgenograms revealed a number of osseous and metallic fragments situated within the brain substance.

Neurologic examination showed an essentially normal status except for visual field defects, which will be described in detail. Repeated sensory examinations with special methods, including application of double simultaneous stimulation, failed to disclose any abnormality. In confrontation tests the patient's fields seemed to have a wedge-shaped defect in the homonymous left lower quadrants (although the patient still maintained that only his left eye was impaired). The ocular muscle balance was normal.

Perimetric and Tangent Screen Studies.—Perimetric and tangent screen studies with a 1 degree target at a distance of 33 cm. and illumination of 7 foot candles confirmed the presence of an absolute scotoma within a sector of the homonymous left inferior quadrants (fig. 6). The fields for red were correspondingly contracted in the affected areas. However, repeated tangent screen tests with targets of varying size showed that within the scotoma there was a small zone of relative vision, extending over the area between 20 and 25 degrees from the fixation point. In this zone, the patient recognized gross motion of a 3 degree target. All around the

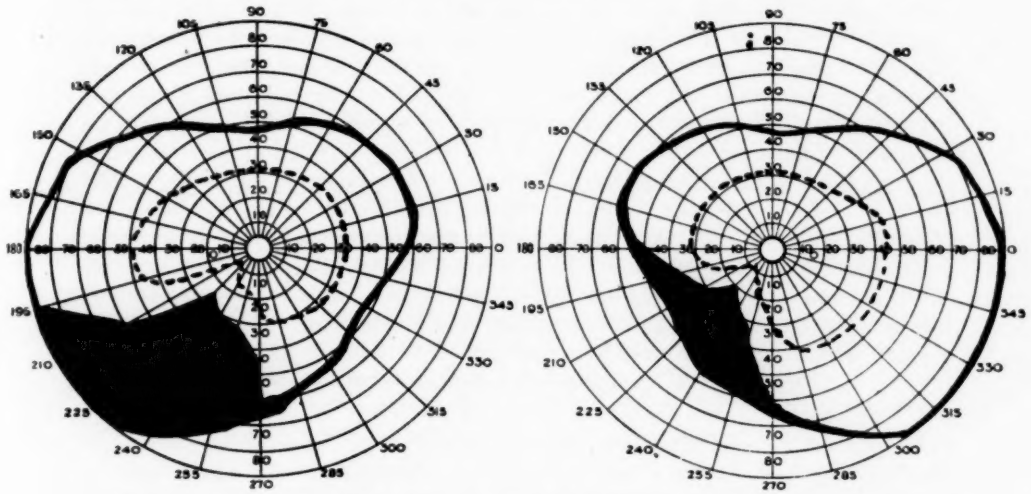

Fig. 6.—Perimetric fields. The solid black indicates the zone of amaurosis (even moving targets were not perceived); the broken lines represent the boundaries of perception of red (1 degree targets under illumination of 7 foot candles at a distance of 33 cm.).

scotoma, in the left lower quadrant, there was some fluctuation of images. A target exposed to this region tended to disappear and reappear. This was the more pronounced the closer the target was held to the margin of the scotoma.

Phenomena of Extinction, Fluctuation and Completion.—A target exposed in the functioning portion of the left lower quadrant would become invisible to the patient whenever he attempted to see an object simultaneously exposed to the right of the fixation point.[1a] Such "extinction" was not obtained on simultaneous double stimulation of the upper and lower quadrants of the left half-fields of vision. The phenomenon of extinction was not elicited with exposure of large targets. If, instead of the standard targets (subtending 1 and 2 degrees), a finger was held against the tangent screen in the seemingly intact portions of the left lower quadrant, and then another finger was presented in the patient's opposite (right) lower quadrant, the finger on the left did not disappear but became "dirty" or gray (obscuration).

In addition to these phenomena of fluctuation, obscuration and extinction, the patient showed a definite "completion" phenomenon. Such completion effects were regularly obtained on high speed tachistoscopic exposure (0.05 to 0.01 second) of continuous figures, parts of which were projected onto the seemingly amaurotic portions of the scotoma. There was no completion with exposures at lower speeds.[1a] Further tests revealed that fluctuation and extinction occurred in the left upper quadrants, but to a much slighter degree and much less often than in the left inferior quadrants.

Aubert-Föster Phenomenon.—Discrimination of forms in the peripheral fields was tested at varying distances under the conditions set up for case 1. The patient showed considerable relative narrowing of the field in the large-far constellation (i.e., an excessive Aubert-Förster phenomenon). Moreover, in the large-far constellation, the entire left half of the field appeared contracted toward the median plane up to 3 to 5 degrees from the center of the field.

Perception of Colors.—As compared with corresponding portions in other quadrants, colors in the area surrounding the scotoma appeared to him to be paler, or "grayish." This was true even for colors produced by simultaneous contrast, by successive contrast and by mixture on the color wheel. If the patient maintained fixation on the center of a large rotating color wheel (the radius of which subtended 80 degrees), he reported that the left lower sector was lighter than the remainder of the disk.

In addition to these disturbances, there were indications that the patient's color vision as a whole had been weakened. He had no difficulty in naming colors, but his after-images were characterized by complete lack of chroma, regardless of what colors were used in the test object. In contrast to normal subjects and the majority of our patients with injuries of the occipital lobe, he was unable to get color effects from a rotating disk bearing an eccentrically placed white figure on a black background. (Such disks, if rotated at a speed sufficient to obliterate the figure and to produce the impression of intense visual flicker, normally elicit striking color phenomena.)

After-Imagery.—In addition to the abnormality of lacking chroma, the after-images in this case were unusual in that their pattern showed significant forms of spatial rearrangement (or disarrangement) of detail. After-images of the American flag (17.5 by 9.2 cm.) drawn in complementary colors[1] were always in black and white. The field of stars appeared deep black and the remainder light or indistinct. In most instances, the outline was distorted, and this in a manner which was not at first sight consistent with the location of the major defect in the field, i.e., the scotoma in the left lower quadrant. During inspection of the original flag, this scotoma produced an area of haziness and eventual blankness in the left lower corner of the flag. In the after-image, the field of stars was displaced downward into the left lower corner of the flag. The total outline thus gave a steplike appearance instead of the oblong shape of the original (fig. 7). Furthermore, this after-image showed a curious independence of the actual orientation in which the original flag had been presented during exposure. For instance, if the original flag was rotated through 180 degrees and then inspected by the patient for sixty seconds with binocular fixation on the stars which he had fixated originally, he again reported an after-image with the shape and orientation shown in figure 7. Evidently, the patient's after-images had many of the characteristics which have been reported in the literature for the so-called eidetic images.[46]

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46. Klüver, H.: (*a*) Eidetic Phenomena, Psychol. Bull. **29**:181, 1932; (*b*) The Eidetic Type, A. Research Nerv. & Ment. Dis., Proc. **14**:150, 1933.

Further Examinations of the Visual Fields by Special Methods.—Measurements of critical frequencies of flicker disclosed an irregular weakening of the greater part of the functional field of vision. Even in the macular region there was a considerable decrease in the thresholds for flicker and fusion, thus showing that the central field was partly defective in function.[47]

In the right half of the field the threshold for fusion was decreased only slightly below the expected normal values. Consequently, the threshold for fusion in the right field at 12 degrees from the fixation point was higher than that in the macular region. To the left of the macular region the threshold values dropped precipitously.

In the tests for the assessment of apparent speed of visually perceived motion, the patient noted that when the rotating disk was exposed in the left lower quadrant of his field it seemed "farther away" and "smaller" than in other parts of the field of vision. With the teleopsia and micropsia, the patient reported that the apparent speed of the rotating disk had likewise increased. As the patient put it: "The little wheel is really whirling around." Thus, in testing the macular area, and the rest of the field of vision, with a Masson disk rotating at standard speeds, it was found that (*a*) the disk appeared to turn most slowly in the right half of the field, somewhat faster in the center and still faster in the left upper quadrant; (*b*) in the left lower quadrant, in concomitance with the apparent dropping back in space and the shrinking in size, the motion became exceedingly swift.

Thresholds for stroboscopic motion were correspondingly altered throughout the field, except for regions in the left lower quadrant adjacent to the scotoma. There, stroboscopic effects were not obtained at all. Instead, there was a curious disorder in the perception of the basic alternating flashes of light.[48] From the outset, our patient failed to perceive the alternation of flashes. Instead, he reported that upper and lower windows were both white simultaneously and then both black immediately afterward, and so on. As the speed of the apparatus increased, fine flicker appeared, and shortly afterward fusion of both windows occurred. When the left lower quadrants were tested, the windows seemed to be "far away."

Spatial Disorientation.—Of all the disturbances noted in the left lower quadrant, spatial disorientation was the most conspicuous and practically constant. This has been noted already in some of the preceding tests. Moreover, in tests of the patient's perception of form in the paracentral fields, he showed varying amounts of metamorphopsia (e. g., squares were perceived as *H*; triangles, sometimes as circles). This was limited to the left lower quadrant. More often forms were

47. In the intact visual field the thresholds for flicker and fusion are highest in the center, or in an immediately adjacent paracentral area; they decrease rapidly, but almost uniformly, in all four quadrants as the area of stimulation is moved farther toward the periphery. Correspondingly, a test object (such as a Masson disk) moving at a standard speed seems to the normal subject to move slowest in the center and appears to move with increasing rapidity as it is exposed farther out toward the periphery.

48. (*a*) Bender, M. B., and Teuber, H. L.: Disorders in the Visual Perception of Motion After Brain Injuries, to be published. (*b*) If the rate of alternation of these flashes is slowly increased, one normally obtains the following sequence of impressions: (1) alternation (i. e., upper window dark, lower window light; then upper window light, lower window dark, etc.); (2) with increase in speed, a stroboscopic motion (i. e., a white flash moving across the screen from the upper to the lower window); (3) then separate flicker in each window; (4), finally, fusion (a steady gray in each window).

correctly recognized and correctly reproduced by the patient, but appeared to be rotated in the two dimensional (coronal) plane. The latter disturbance was also occasionally noted in the superior quadrant on the left. For instance, a large, slender isosceles triangle standing on its base on exposure to the patient's left upper quadrant appeared to be turned in such fashion that its apex pointed downward and at a 45 degree angle toward the center of fixation. Both changes in shape and rotations in the coronal plane were most pronounced near the medial borders of the wedge-shaped scotoma in the left inferior quadrant.

Pointing Tests.—The patient was instructed to point at objects exposed at varying distances from his eyes and at varying degrees of eccentricity from his center of fixation. With his central vision, localization in visual space with either hand was correct. With his extramacular vision, his ability to localize objects in the right half-field of vision was normal, but was decidedly abnormal in the left half-field. The deficiency in localization in the left homonymous fields was most pronounced in the lower quadrants. In the left upper quadrants he missed the object by pointing beyond it (in the sagittal plane) and medially. In the left inferior quadrant the past pointing in the sagittal plane was gross. There he always past pointed (*a*) upward (i. e., toward the horizontal meridian), (*b*) medially (i. e., toward the vertical meridian), and (*c*) considerably beyond the object (i. e., in the sagittal plane). The past pointing beyond the object was by far the most pronounced. This deficiency in localization agreed well with the patient's subjective complaint that things practically always looked "too far" in his left lower quadrant.

However, the extent of the past pointing (and hence, by inference, the perceptual displacement) varied from trial to trial. The extent was primarily a function of two factors: (*a*) the location of the target within the field and (*b*) duration of exposure of the target. The area of maximum disturbance in pointing was found to be in the left lower quadrant, extending from 10 to 15 degrees from the fixation point. In addition, the past pointing in all directions was most pronounced if the target was moved farther away from the patient in the sagittal plane. The distance of a target held at 5 to 10 degrees from the fixation point and moved steadily away from the patient was increasingly overestimated.

The second factor influencing the teleopsia was the time of exposure. The longer an object was exposed (even if its relative distances from the patient's eyes and from the center of fixation were not changed), the more it seemed to the patient to "drift backward" in space. It should be recalled here that on prolonged exposure of an object on the tachistoscope or with double simultaneous exposure the target in the left lower quadrant became visually "extinct."

Pointing in Dark Room at Single Targets.—The examination room was darkened so that the patient saw only a dimly illuminated (15 millilamberts) background (milk glass screen 34.6 by 43.2 cm.). A fixation mark was placed in the center of the screen. A well defined beam of light was then projected on the screen from behind, and the patient was instructed to point at the resulting disk of light (which subtended 3 degrees), at 4 and 8 degrees of eccentricity along the 45 degrees meridians in the various quadrants. When these stimuli were presented in his left lower quadrants with time exposure, the patient past pointed as much as he had in a normally illuminated room. Even if the tests were preceded by twenty minutes of dark adaptation, his performance did not materially improve. However, with rapid tachistoscopic exposure (0.01 second) there was little, if any, past pointing. Here, again, with short exposure of objects, visual function (localization in space) seemed little impaired.

Bisection of Lines.—As in most cases of disorder in visual space, tests of bisection of lines were particularly revealing of the prevailing tendencies toward distortion in the spatial coordinates of the patient's field. He tended to underestimate the peripheral portions of the lines which were oriented horizontally to the right of his center of fixation and of those which were vertically above it. On the other hand, he consistently overestimated the peripheral portions of lines which were oriented along the lower vertical and/or the left horizontal meridian (fig. 8).[38] Further trials with lines in various intermediate meridians confirmed the conclusion that the more peripheral extensions in the left lower quadrant appeared to the patient shorter than they would to a normal observer. Consequently, there was a tendency to make the peripheral portions of lines in this quadrant too long.

In addition, this spatial distortion in the left lower quadrant influenced the rest of the field. There were errors in bisection in the right field, but it is noteworthy that the subjective midpoint was again displaced to the right. Hence, this time the peripheral portion of the line appeared to him longer than to a normal observer. When the patient was asked to place a dot in the center of a circle which was exposed eccentrically in each of the four quadrants, he erred in a fashion consistent with that which had become evident on attempted bisection of

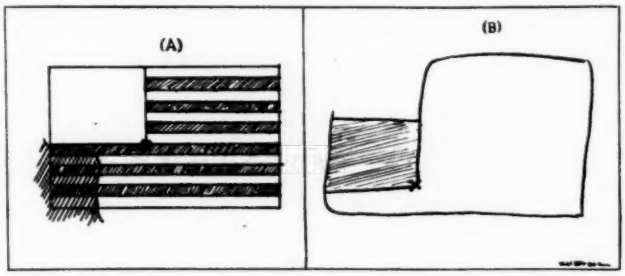

Fig. 7.—After-imagery. *A*, schematic drawing of the test object, an American flag (7.5 by 9.2 cm.) in complementary colors (i.e., red stripes rendered in blue; white stripes, in black; field of stars, in yellow). The patient maintained fixation on *X* for fifteen seconds. The heavy diagonal shading corresponds to an area (in the left lower quadrant) which the patient did not see during fixation on *X*. *B*, what the patient saw in the after-image. The field of stars (which appeared to him as black) was displaced downward in relation to the rest of the flag (which appeared as light gray). This displacement represents a form of spatial disorientation.

lines. All these difficulties were noted on binocular, as well as on monocular, fixation. However, the errors and distortions were regularly more pronounced when the patient used his left eye than when he used his right eye.

The results suggested a partial constriction of the field—as though the patient's functional fovea had shifted away from its anatomic site, to the right and upward along the 45 degree meridian into the right upper quadrant. In point of fact, tachistoscopic examinations with letters and figures irregularly distributed over the whole field confirmed that an area of highest efficiency was located in a pericentral region of the patient's right upper quadrant, or diametrically opposite the patient's scotoma.

Associated Disturbances in Size and Shape.—During tachistoscopic examination another abnormality in visual perception was noted. This was found to be related to the disorder in visual space and manifested itself as an alteration in size and shape. On rapid exposure of continuous figures (circles, squares and triangles)

in the center of the field, the patient reported that they appeared to him much larger than they did when they were exposed for a longer period. This apparent macropsia was accompanied with a disturbance in localization in the sagittal plane. The patient reported that the image was nearer to him than on slow or prolonged exposure. Evidently, this patient, like many others with disorders in visual space, showed concomitant alterations in the perception of size and shape.

For this reason, a number of special tests of constancy of size and form were carried out. These will be described in detail in a future communication. However, the salient features of these studies were as follows:

(*a*) On monocular and binocular testing, the teleopsia on the left was the rule, while concomitantly perceived changes in size and shape showed considerable variability.

(*b*) If the saliency (prominence) of a test object exhibited to the left lower quadrant was increased (e. g., by training a spotlight on it), the degree of the

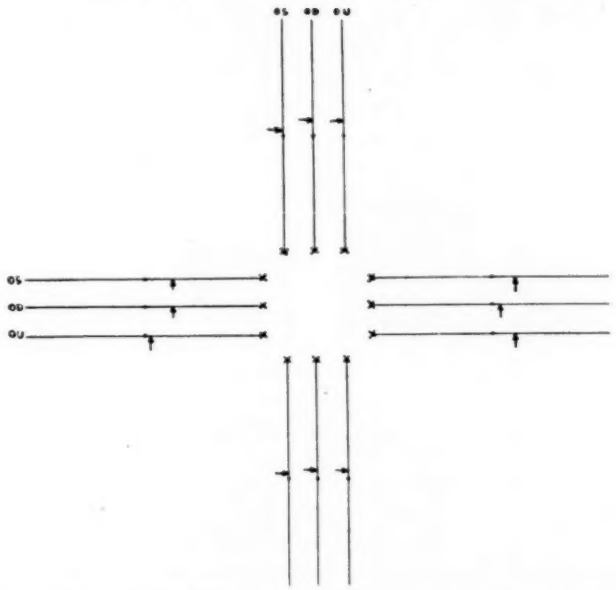

Fig. 8.—Patient's attempts to bisect lines presented in the horizontal and vertical meridians. He was instructed to fix the line at the point *X* with the right eye (*OD*), with the left eye (*OS*) and with both (*OU*) eyes. For details, see the legend for figure 3.

micropsia diminished. However, there was no change in the degree of teleopsia in this case.

(*c*) Under certain conditions of double simultaneous stimulation (to the right and left of the median plane), the illusion of teleopsia on the left could be modified, or even reversed. In this way, "pelopsia" (or the illusion of abnormal nearness), with pronounced micropsia, resulted on the left, and a form of teleopsia with macropsia, on the right.

Although the source of the disturbance in spatial organization seemed to be largely on the left, certain special stimulus configurations exposed to all four quadrants of the field thus demonstrated a latent distortion in visual space for the field as a whole.

Experimentally Induced Teleopsia.—The lability in perceived distance and size in the patient's visual field could be further elucidated with the use of moving stimuli, which induced changes in apparent distance and size. This was done in the following manner: A black disk 8½ inches (21.5 cm.) in diameter, mounted on a black panel, was exposed in the coronal plane at a distance of 1 meter from the patient's eyes. On the black disk a logarithmic spiral was drawn in white (Plateau spiral). With slow motion, such a spiral (to the normal observer) gives the impression of rhythmically expanding circles, similar to the circular ripples set off by a pebble dropped into water.

When the disk was stationary and exposed largely in the left lower quadrant, and partly in the left upper quadrant, of the patient's field of vision, he reported that it seemed to be "half as big" and "a little farther" than it did on central fixation. The spiral was then exposed in the right half of the field and set in motion. The patient reported the normal effect, a radial expansion in the coronal plane. When the spiral was in the central field and rotating, he had the following illusion: Instead of expanding in a plane, the disk seemed to move toward the patient along the nodal line. As this illusory movement continued, he became aware of an increasing distortion in the shape of the disk. Along its vertical meridian, the disk appeared bent and stretched; its entire right half seemed nearer and nearer, and its left half, farther and farther away.

The entire rotating disk was then exposed in the left half of the patient's field. He immediately reported that the disk was rapidly "drifting away" (in the sagittal plane). This induced teleopsia was much more pronounced than that observed for the stationary disk. Moreover, it was clearly related to the actual speed at which the spiral rotated. As the speed increased, the teleopsia became more evident.

The speed was then further increased, to the point at which the patient experienced fusion, i. e., at which the disk appeared to him motionless and uniformly gray. As soon as this critical speed had been reached, the disk appeared immediately less distant (i. e., the teleopsia decreased). At this stage the illusions were thus again the same as those for the stationary disk.

When these series of observations were carried out in a descending order, i. e., wtih decreasing speeds of rotation, the previous results were confirmed. The effects were, therefore, not due to the order of presentation. They were the direct perceptual response to the modification of the stimulus pattern which had been achieved by rotation and by fusion.

Binocular Rivalry, Fusion and Depth.—Numerous experiments with a refracting stereoscope were undertaken to analyze the patient's binocular depth perception (fig. 9).

1. Binocular fusion for simple outline figures was obtained. However, rivalry between the left and the right eye was intense. The figure presented to the left eye was frequently suppressed. When fusion was obtained, it was often incomplete. The left lower portion of the figure presented to the left eye faded, became distant, fluctuated in distinctness and was ultimately obliterated (extinction phenomenon; fig. 9, *1*).

2. During maintained fusion, even the central portion of the figure presented in the left eye became unstable in its position in relation to the rest of the binocularly fused fields (fig. 9, *2*). There was a rhythmic displacement of the central portion presented to the left eye, and always to the right of the midline (an illusion of motion). As the part of the image moved to the right, it also seemed to come closer to the patient. When it moved back toward the center, it seemed to recede.

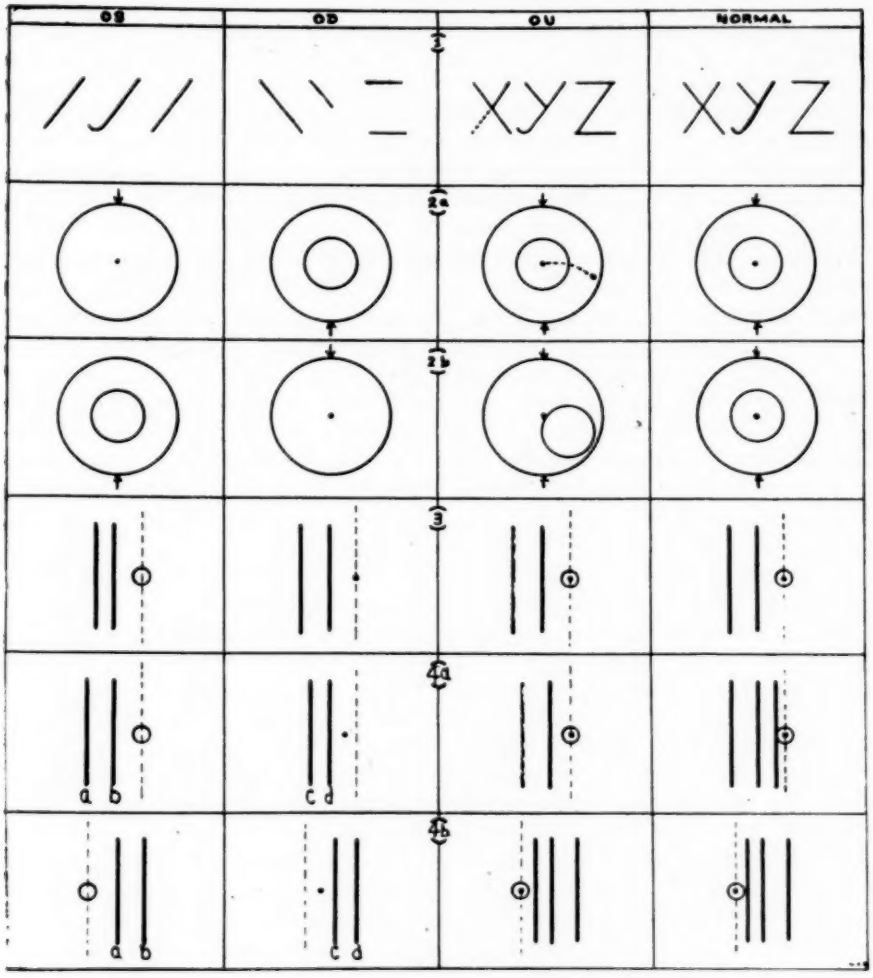

Fig. 9.—Designs used for tests of binocular fusion and stereoscopic depth perception. All figures were exposed in a refracting stereoscope. Figures in the column labeled *OS* were presented to the patient's left eye; figures in column *OD*, to his right eye. The patient's resultant binocular impressions are indicated in the next column (*OU*). The last column (*Normal*) presents the results of binocular fusion of the same designs in normal subjects. Outstanding abnormalities in the patient's binocular impressions were: (*1*) blurring and fluctuation of the left lower portion of the image, and (*2*) displacements and apparent motions, involving even parts of a monocular image (in *2a* the dot [from the figure presented to the left eye] appeared to migrate to the right. In *2b* the circle [again from the left eye] was similarly displaced to the right); *3* and *4*, illustrating variations of the Panum pattern. The patient's responses indicated persistence of the teleopsia on the left (e.g., in *3* and *4a*, the line to the left appeared faded and "far away"). *4a* demonstrates, in addition, his abnormal ability for the fusion of disparate lines. He fused line *a* with line *c*, and line *b* with line *d*. By contrast, normal subjects fused only two lines (e.g., *b* with *c*), thus obtaining a binocular impression of three lines. If the same patterns as those shown in *4a* were presented to the right of the midline (*4b*) the patient's response was the same as that of a normal subject.

3. Although binocular fusion, if not complete, could be obtained by the patient for the major part of his field, stereoscopic depth effects could never be produced. He failed to get depth for familiar objects, as well as in the classic instances of stereoscopic depth produced by horizontal disparity of simple line patterns, such as the Panum phenomenon [49] or the truncated cones.

4. By means of the Panum pattern, it could likewise be demonstrated that the patient's abnormal depth effects (teleopsia) in the left half of his field were so persistent that they could not be offset by a binocular disparity working in the opposite direction. If one interchanges (for a normal subject) the pairs of lines of the Panum pattern which are presented to each eye, the relief in the resulting binocular image is reversed; for our patient, however, the line to the left invariably appeared farther away and fainter than the one to the right, regardless of the relative positions of the component monocular images.[50]

5. Tests with a number of variations of the Panum pattern confirmed the predominance of the left-sided teleopsia over any possible influence of binocular disparity. (*a*) When each pair of lines was placed to the left of the midvertical meridian (fig. 9, *3*) perfect fusion was obtained. The patient reported two lines to the left, and the one to the extreme left appeared to him faint and distant. But this impression persisted on occluding either eye. The greater depth of the left line was, therefore, due not to normal stereoscopic vision (binocular disparity) but to the patient's characteristic left-sided teleopsia. (*b*) When the pairs of lines were placed to the right of the midvertical meridian, fusion was made exceedingly difficult. Whenever the patient did see two lines in what seemed to be binocular fusion, he failed to obtain any concomitant depth effects. (*c*) The basic Panum pattern was finally modified in such a way that perfect fusion of the monocularly presented pairs of lines into a single binocular pair of lines became impossible for the normal observer. Under these conditions (represented in figure 9, *4*), our patient obtained the same impression as a normal observer whenever the lines were in his right half-field—that is, he reported three lines (fig. 9, *4 b*). However, when the pairs of lines were to the left of the median, the patient demonstrated an abnormal degree of fusion ability; that is, he reported an image of two lines, which could be proved to be built up by perfect binocular fusion of the four presented lines (fig. 9, *4 a*). As usual, the line to the extreme left appeared farthest away.

Disturbances in Visual Space as Evidenced in Drawings and Maps.—Perspective Drawings: The patient was given a series of two dimensional line patterns, depicting three dimensional forms (perspective drawings). Figure 10 illustrates his attempts at copying these patterns. His productions were characterized by a total lack of perspective. He was aware of this difficulty. Looking at test figure 10 *c*, depicting a reversible cube, he said: "This is a box, but I just can't draw

49. Woodworth, R. S.: Experimental Psychology, New York, Henry Holt & Company, 1938.

50. In order to be able to draw this conclusion with reasonable certainty, great care had to be taken to insure that the patient's perception was actually based on binocular fusion of the images presented to either eye. This was all the more necessary since it could be demonstrated (by occluding either eye) that the teleopsia on the left persisted even on monocular viewing of a test pattern. The control of binocular vision was achieved by adding various marks to each test slide—e. g., a dot for the right pattern and a circle for the left (fig. 9, *3* and *4*). Whenever the dot appeared to be (for the patient) in the center of the circle, it was assumed that the patient was converging and using both eyes at that moment.

boxes." In his drawings of this "box" (fig. 10 *c,1,2*), he attempted evidently to indicate the number of plane surfaces but failed to arrange them properly in space.

Free Drawings: A similar absence of perspective was evident in the patient's free drawings. Various attempts to portray "a table with a checkerboard and a glass of water" resulted in structures which could be easily recognized. There was no inkling of the characteristic disarrangement of details which has been found in cases of severe spatial disorientation.[27] But the patient drew exclusively those features of the object which appeared in his coronal plane. Portions of the object which were actually behind this plane either were omitted (thus, a table invariably had only two legs) or were rotated out of their actual position until they fell in the frontoparallel plane. Thus, the checkerboard was drawn as though standing on edge, with the checkered surface fully facing the observer.

Spontaneous Writing: The patient centered the lines properly on the page. The lines were parallel and more or less equidistant. However, he was unable

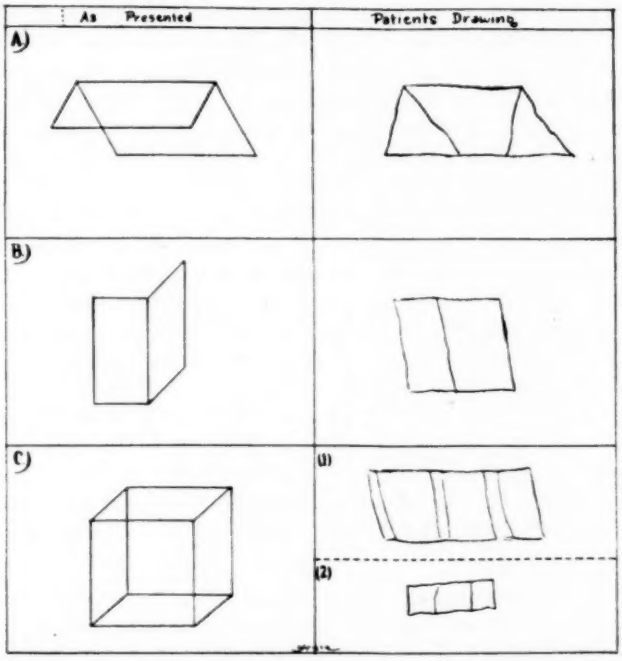

Fig. 10.—Left column: Presented patterns (bidimensional drawings, suggesting various tridimensional figures). Right column: Patient's attempts to copy the presented patterns. Note absence of perspective.

to write in this fashion as soon as he was prevented from orienting the page in his preferred manner; he always rotated the sheet through 90 degrees so that the left margin became the bottom and was in a frontoparallel plane with respect to himself. Then he proceeded to write perpendicularly to the lower edge of the paper. The patient insisted that he never wrote in this manner until after his battle injury.

Stick Test of Goldstein and Scheerer[43]: The patient performed normally in copying patterns, as well as on delayed recall. However, his free designs built up from an unlimited number of sticks presented curious "abbreviations," which led to moderate spatial distortions not dissimilar to those found in the patient's free drawings.

Head Clock Test[29b]: He made characteristic errors, which consisted in misplacing the big hand from the lower left into the upper left sector of the dial (fig. 11). The patient's attempts at drawing little maps of familiar routes and ground plans of his ward and the examination room were usually correct. However, there was a tendency to include innumerable details. He did not seem to be able to use salient features of the route as points of reference, or landmarks. Instead, he insisted on including every single building and every single turn along the route he was told to depict. Route finding in itself was entirely undisturbed, as was the patient's spatial organization when he had his eyes closed. The latter was tested by having the patient change seats with the examiner, close both eyes and then point at the familiar objects in the examining room. Under these complex conditions, he performed without appreciable error.

Sorting Behavior: However, a diffuse and generalized qualitative change in the patient's intellectual processes was unmistakable in his sorting behavior.[48] In his free grouping of objects, he employed only a single category, namely, the common use of the objects. Even with strong suggestion, he was unable to shift to a different principle of sorting. In addition, his behavior in sorting was determined by what seemed to the examiner insignificant detail. Thus, two ink bottles were not grouped together, "because," as the subject pointed out, "one was empty."

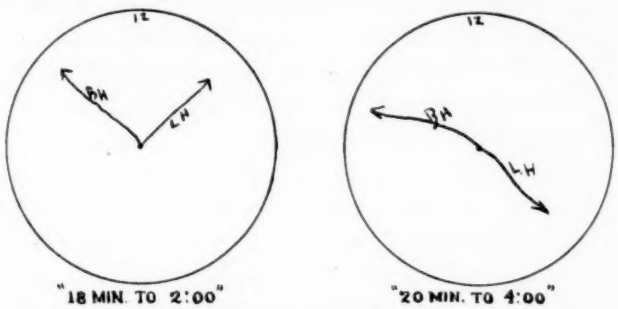

Fig. 11.—Clock test. The patient was given sheets of cardboard bearing an outline circle with a dot in the center. He was instructed to transform the circle into the dial of a clock by inserting a number *12* on top, and by drawing a big hand and a little hand in positions appropriate to the various times indicated to him. Two examples of such clock setting are given, illustrating how this patient erred by avoiding the left lower sector of the dial.

He also insisted on putting the objects close together, and evidently needed their actual proximity in order to be able to "group" them together in a conceptual sense. He frequently complained of the difficulty of the task. However, there were no bizarre responses. His behavior was similar throughout to that of other patients with fairly extensive damage to the brain.

As in most other cases of injury to the brain, the results of the standard psychometric tests were difficult to interpret. On the Wechsler-Bellevue intelligence scale, the patient earned a total score of 82, placing him in the "dull normal" range. However, the equivalent of his general classification test, administered prior to his injury, was approximately the same. The only fact of possible significance was his specific inability to solve visual-constructive tasks, as represented by the block designs and picture completion subtests.[51]

51. Working with a number of psychometric tests, Hebb (Hebb, D. O.: Intelligence in Man After Large Removals of Cerebral Tissue, J. Gen. Psychol. **21**:437,

(Footnote continued on next page)

Rorschach and Behn-Rorschach records obtained during the period of administration of special visual tests were consistent with an impression of low average intelligence. Form was poorly perceived, and there was some perseveration in content. There were indications of moderate anxiety. However, none of the other presumably pathognomonic responses was elicited, nor was there any bizarre reaction. On the whole, psychometric and personality studies failed to give conclusive evidence of the existence of post-traumatic intellectual impairment. But the results were not inconsistent with the findings of specific disabilities for visual tasks and of a more subtle change in intellectual approach, as suggested by the special clinical studies.

Comment.—This case shows a disorder in the visual perception of spatial relations which is closely similar to the one previously described. However, in several respects the disturbances in this case were severer.

1. With gross testing, the disorientation in visual space was present in the left homonymous halves of the fields, but was most pronounced in the lower quadrants. The perimetric and tangent screen examinations disclosed a scotoma in a sector of the homonymous left lower quadrants. In the area surrounding the scotoma, and, to a lesser extent, in the superior quadrant on the left side, one could note the phenomena of fluctuation and, on double simultaneous stimulation, obscuration and extinction. Color vision was defective.

2. Measurement of fusion frequencies of visual flicker, thresholds of stroboscopic motion, assessment of phenomenal speed and evaluation of after-imagery all showed extensive involvement of the left homonymous fields of vision, being most pronounced in the left lower quadrants. However, to a less extent, the macular region was also implicated. Tachistoscopic studies revealed that an eccentric area of highest visual efficiency was situated to the right of the median plane and slightly upward from the objective center of the field.

3. The spatial disorientation in the left half-field involved all three dimensions, but was most pronounced in the sagittal plane. The patient experienced an illusion of excessive depth (teleopsia), and frequently a concomitant alteration in size, shape and hue. As a rule, there was micropsia, but under certain conditions (especially with unfamiliar objects) the patient's responses indicated teleopsia with macropsia. All these defects were found on monocular and binocular testing.

4. Confirmatory evidence was obtained by means of the stereoscope. Teleopsia was found to be present to the left of the midline. The teleopsia was so strong that it could not be overcome by binocular parallax. The patient could fuse the component monocular images, but he never obtained a truly binocular depth effect. In the left half of the field, the patient could binocularly fuse linear patterns which

1939) found gross selective breakdown on standard performance tests of intelligence of the visual-constructive variety in a patient whose right temporal lobe had been partly removed.

were so disparate that a normal subject could never bring them to fusion. The latter observations were repeatedly confirmed on various examinations.

5. As in case 1, the patient's performance in the bisecting of lines in this case suggested that the coordinates of his subjective visual field had undergone a systematic deformation. This situation could be described by saying that the principal coordinates of the subjective field of vision had shifted to the right, or away from the area of greatest disturbance in the left lower quadrant. The patient's subjective visual space thus no longer coincided with his tactile, or locomotor, space. As a result of this discrepancy between the patient's visual and his nonvisual space system, one finds the constant errors in pointing and bisection.

In addition to this integral shift of coordinates, there was the decided, and fairly persistent, tendency toward distortion, which was at a maximum in the homonymous left lower quadrants. This alteration seemed to be somehow inherent in the "framework" of the patient's perceptual organization, since all visual perceptions were distorted in a highly consistent fashion. It was primarily manifested in the excessive depth effects (teleopsia) in the left lower portion of the field; in the simultaneous medial displacement of images (which surpassed in extent the displacement noted in any other quadrant), and, occasionally, in distortions of perceived shapes.

6. As in the first case, all these alterations in visual space perception and the concomitant changes in size and shape could be modified, in spite of their persistence, and even temporarily reversed under certain experimental conditions. Whatever the exact nature of the changes in function of the occipital lobe which were responsible for the alterations in his subjective visuospatial framework, the observations suggest that the underlying disorder was not a static condition, but an active process.

7. This patient showed considerably more disturbances on objective testing of his visual performance than did the first patient. With this, there were more clinical symptoms and a more persistent awareness of his visual difficulties.

GENERAL COMMENT

These case studies illustrate only some of the numerous disorders in the perception of visuospatial relations which were seen in a series of patients with battle injuries of the brain. In fact, spatial disorientation was commonly found in areas of the field with deficient visual function. The disorientation was as a rule in all three dimensions and was always accompanied with changes in apparent size, shape and hue. The disorders were often limited to a quadrant, or even sector, of the field and seemed to be most frequent in the neighborhood of scotomas of unequal density.

As Riddoch [25d] pointed out, such spatial disorientation may occur in an apparently normal field of vision. However, we emphasized the fact that the integrity of these fields is only apparent. Special methods of examination of visual functions in such cases reveal a reduction in the thresholds for fusion of visual flicker, impairment of ability to perceive stroboscopic motion, defective after-imagery and other modifications of visual perception which have already been mentioned.[52]

By means of these methods, it can be shown that the various visual functions are systematically altered. Indeed, we have never noted that any function was lost entirely by itself. In this respect, the symptoms (even though based on limited defects of the field) corresponded to the situation described by Poppelreuter [8] for patients with massive destruction of the occipital lobes, in the first world war, and by Klüver [29d] in his reports on bilateral ablations of the occipital lobe in monkeys. Even in areas of almost complete amaurosis, all the functions which could still be tested were found to have changed in an integral fashion. Among the many functions so altered was that of localization in visual space.

Analysis of the disorders in perception of visual space revealed that the alteration was most apparent in the sagittal plane. As a rule, the patients experienced an excess of depth (teleopsia), although at times there was a sudden reversal, with resultant illusions of excessive nearness ("pelopsia"). In the coronal plane, the disorientation manifested itself in the form of displacements and distortions, in directions which were consistent for each patient. It was therefore not a question of "indeterminate" or erratic localization. In both the coronal and the sagittal plane, the disorientation appeared as a systematic and persistent change in the coordinates of the patient's subjective visual space.

It is evident, then, that these phenomena cannot be explained in terms of any associationistic or quasiassociationistic theory of depth perception. These patients have not lost their ability to interpret or integrate cues of depth. Neither the systematic nature of the disorder nor the concentration in homonymous quadrants could be understood on any simple associationistic basis.

On the other hand, the observed displacements in all three dimensions of space were never of an all or none character. They could be shown to depend on conditions of stimulation. The symptoms could, therefore, not be explained in terms of an alteration or a loss of (static) "local signs."

In these circumstances, one might consider a reformulation of the symptomatology in terms of the field theory. For the gestalt theorist, organization of percepts in tridimensional space is to be interpreted

52. We also had the opportunity to study a patient with gross disorders in visual space perception (limited largely to a quadrant of the field of vision) following an injury to the occipital lobe. In this patient the disorientation was so marked that he was unable to detect even the direction of a given movement.

as the result of a more or less spontaneous distribution within a field of hypothetic "forces," which tend toward maximal equilibrium. Thus, stresses set up by an asymmetric bidimensional pattern, such as the Necker cube (fig. 10 *C*), will lead to a tridimensional organization, in which the pattern becomes "simpler" or more symmetric.

Even with the normal subject this tridimensional organization may be labile. This "dynamic" and fluid character of depth perception is impressed on any normal observer who views the Necker cube for a certain time. For the pattern, like many others, appears reversible: Figure and background interchange at a definite rate, with a concomitant reversal in depth effect. A similar lability and reversibility had been noted for the abnormal depth effect in our cases.

It will be recalled that in our cases the teleopsia was not absolutely constant. It could be neutralized by certain stimulus configurations, by modes of presentation, such as tachistoscopy, and in after-imagery. Moreover, the teleopsia could be changed to a pelopsia under certain experimental conditions (e. g., double simultaneous stimulation with objects of unequal size). It was evident that the teleopsia took time to develop, that it was dependent on the stimulus distribution in the field as a whole and that it was at a maximum in the most impaired sector of the field of vision.

Our hypothesis, therefore, is that the underlying active process was influenced by an irregular weakening in the cortical field: Normal "stresses" toward tridimensional organization persisted throughout the field. However, in the most implicated quadrant figures had become more labile (or lost part of their normal resistance against displacement). As a result, the patients experienced lateral displacement and abnormal depth phenomena. These effects became more pronounced as exposure was prolonged, or as the articulation of the field decreased.

It is important to note what assumptions are being made in such an interpretation of the symptoms in terms of a field theory. Evidently, one must consider two sets of "vectors": (*a*) those accounting for the excessive depth in the impaired sectors of the field, and (*b*) those accounting for the (predominantly medial) displacements in the coronal plane.[53] One could reformulate the first set of vectors (*a*) more generally as the tendency of the visual field to become as large (and "deep") as possible.[54] The second set of vectors (*b*) would tend to

53. Similar assumptions were made by Brown and Voth[21] and by Orbison.[20] They postulated a duplicity of vectors, viz., cohesive and restraining field forces. The effect of the former is "to attract objects" and to "cause them to flow together." Working in an opposite direction are the restraining forces, which give stability to the perceived objects within the field. Under normal conditions of formation of visual patterns, the two sets of forces are in balance, and configurations exhibit a resistance against displacement. Neither Brown and Voth nor Orbison, however, considered displacements in the third dimension.

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make the visual field as "narrow" as possible, thus accounting for the frequent displacements in the coronal plane.

The assumption of these two sets of vectors does not "explain" the observed effects. It merely reformulates them in a fashion which makes it possible to consider a continuity between normal and abnormal depth perception. Even the mere postulation of field forces necessitates a further important assumption, viz., that the spatial projection of the retina onto the striate cortex has actually a functional significance.[55]

However, in spite of its limitations, the vector-field theory may have considerable descriptive value. Even minor details of the symptoms become understandable in terms of the hypothesis, such as (1) the patients' excessive ability for binocular fusion of disparate patterns (in the affected part of the field) and (2) the observations made on exposure of the rotating and stationary Plateau spiral.

1. To bring about binocular fusion of disparate images in the normal visual apparatus, one part of a monocular figure is necessarily displaced (fig. 9, *3*). When the disparity in the figures is moderate, there seems to be a definite "stress" toward fusion. Fusion is practically inevitable. On the other hand, when the disparity in these figures is great, fusion is not attained. The "stress" toward fusion has frequently been defined as a "field force," tending toward unitary contour (or "simpler" or "better" gestalt).[56] In opposition to this, there is another "force," representing the resistance (on the part of the monocular image)

54. The suggestion of such a tendency for the normal visual field apparently came from Köhler (Koffka[56]). Koffka introduced it into the discussion of the phenomenon of so-called size constancy: The perceived size of a figure which is being moved away from the observer shows only slight decrease (at least over a certain range), even though the objective size of its retinal projection decreases rapidly, i. e., in direct proportion to the distance. This could be restated as follows: The increase in apparent distance, over a certain range, is accompanied with the emergence of a relative macropsia in the normal observer. As a figure is successively localized farther away in perceptual space, it "expands," i. e., gains in apparent size. The latter effect would then partly offset the actual shrinking in size of the retinal image. Conversely, the "effort" of bringing a figure close, e. g., by looking at it through a plus lens, makes the figure appear more "vivid" but at the same time abnormally small (lens micropsia, or "Koster phenomenon").[40a] Such speculations about the relation between perceived distance and perceived size find a certain support in the fact that our patients tended to experience a teleopsia with macropsia whenever they were confronted with unfamiliar visual material.

55. Such a view has more recently been questioned by Lashley (Lashley, K. S.: Thalamo-Cortical Connections of the Rat's Brain, J. Comp. Neurol. **75**:67, 1941), who stressed that the anterior thalamic nuclei also have a cortical projection, although there is no conceivable functional significance in this anatomic fact. Compare, however, Lashley's earlier view of the matter (Lashley, K. S.: Functional Determinants of Cerebral Localization, Arch. Neurol. & Psychiat. **38**:371 [Aug.] 1937).

56. Koffka, K.: Principles of Gestalt Psychology, New York, Harcourt, Brace and Company, 1935.

against being displaced in space. With slight disparity, the stress toward unification is strong enough to overcome this resistance. In the case of our patient, we might assume that the resistance against displacement of the figure was weakened by the defect. Hence, the normal stress toward fusion became seemingly overactive.

2. The findings in the experiments with the Plateau spiral could be interpreted in a similar fashion. Here, again, the normal subject experiences displacement of parts of the figure, viz., the apparent radial expansion of the inner turns of the spiral during rotation. Again, it may be hypothesized that a "stress" is set up by this special stimulus configuration which overcomes the usual resistance (inherent in any figure) against displacement. In our patient, exposure of the rotating spiral in the field of vision resulted in an abnormal yielding to the stress, because the normal resistance to displacement was weakened by the defect in the left half-field. The resultant effect was twofold, involving displacement in all three dimensions of space: (1) The disk itself became larger (displacement in the coronal plane), and (2) the teleopsia became more pronounced (displacement in the sagittal plane).

A further point in favor of an interpretation in terms of the field theory is the striking similarity which obtains between the more or less permanent and severe changes in spatial organization in our patients and certain transient changes in depth perception which Köhler and Wallach were able to induce by "overstimulating" sectors of a normal visual field. In their study of figural after-effects, Köhler and Wallach [22] demonstrated that the prolonged viewing of outline patterns in any part of the visual field makes a difference in the appearance of other patterns exposed subsequently in the same, or closely adjacent, regions of the field of vision. Working exclusively with normal subjects, they were able to show that test objects in the previously stimulated, or "satiated," regions appeared invariably "grayish" and "farther away." Moreover, the test objects frequently appeared changed in size and in shape and showed various forms of displacement in the coronal plane.

The specific points of agreement between the major symptoms of our patients with injury to the brain and those of Köhler and Wallach's normal subjects are as follows: 1. The "depth" effect, i. e., receding of the object in space, was associated with a pale, "grayish" appearance. This was the most constant finding both in Köhler and Wallach's cases and in our own. 2. Size effects, i. e., concomitant changes in apparent size, were apparently less constant than the depth effect. Köhler and Wallach found repeatedly a concomitant increase in size (teleopsia with macropsia). 3. A frequent effect of "satiation" was a distortion of lines, and, at times, displacement of entire figures in the coronal plane. 4. Köhler and Wallach further mentioned that their subjects temporarily lost the ability to use binocular parallax (on the stereoscope). This loss was limited to the "satiated" portions of the

field. 5. Finally, Köhler and Wallach and their subjects were constantly made aware of a curious difference between the upper and the lower quadrants of the field of vision with regard to "satiation." After-effects were always stronger in the lower half of the field. This might be related to the tendency in our entire series of patients to show more disturbances in the lower quadrants.[57] The analogy between the transient "satiation" effects discovered by Köhler and Wallach in normal subjects and the permanent (pathologic) changes in our patients is so close that any physiologic theory of the Köhler effect will apply to our cases, and vice versa.[58]

Such a physiologic implementation of the field theory in perception is both necessary and exceedingly difficult in the present state of ignorance about the cortical correlates of perceptual activity. Conceivably, the pathologic material holds the clues to an identification of some of these correlates. Yet such an identification cannot be anything but tentative until more observations on widely different types of cerebral injuries are made. A further difficulty is created by the global character of the perceptual disturbance. It has been emphasized that the perceptual organization of our patients had changed in an integral fashion. It becomes difficult, therefore, to select from the many perceptual changes which were associated with the alterations in visual space the particular function which might conceivably be "responsible" for the changes in space perception, as well as the underlying changes in the "field."

In point of fact, such a procedure of isolating special functions may be artificial and misleading. If the type of spatial disorientation which we described is indeed an indissoluble feature of a more generalized change in visual perceptions, it might prove impossible to relate the visuospatial aspect to any single associated factor. The fundamental alteration in cerebral function (underlying the changes in perceptual organization) probably cuts across any and all traditional psychophysical categories, such as color vision and motion acuity. We shall therefore limit ourselves to a tentative implementation of the inferred "vectors" which determine localization in the coronal plane.

It was pointed out that our patients showed definite reduction in visual efficiency in the most implicated regions of their fields. This was shown by an increase in various thresholds, e. g., for apparent

57. That field defects resulting from battle injury are more frequently found in the lower half of the field had, of course, already been realized and commented on during World War I. However, the interpretation was usually in anatomic terms: Patients with defects in the upper half of the field have less chance to survive (because of the proximity of the lower lip of the calcarine fissure to vital centers [Klüver [12]]).

58. Köhler's own interpretation, which he formulated in terms of the field theory, thus far does not attempt to account for the depth effect.

motion, and by a corresponding decrease in critical frequencies of flicker. All these changes could be considered as a "lowering" of, or at least a specific alteration in, the excitability of the corresponding sector of the substrate. By contrast, in the intact visual field, excitability is known to fall off fairly symmetrically in all directions from the fovea, which (under conditions of light adaptation) is the center of highest excitability. For the dark-adapted eye the situation is not too different: Excitability again decreases as one leaves an area closely adjacent to the fovea. A similar state of affairs might be assumed to exist in the "cortical field."[59] There a central area (macular projection) represents the locus of highest excitability. Fixation movements of the eyes are normally active to hold any perceptual activity in this area, or to shift it into this area (from the peripheral regions of the field), in a fashion reminiscent of the phototropic reactions of lower organisms.[60]

As a result of this differential sensitivity, normal visual space has a central point of reference, or a subjective "straight ahead." Relative to this area, all visual images are localized in the coronal plane. A distortion of the normal gradients of sensitivity consequent to a defect in a particular sector would therefore result in lability, or even in a shift of this functional center.

The existence of such gradients in sensitivity might be considered as one of the physiologic determinants of organized visual space, at least in the coronal plane. Moreover, approximately equal gradients in excitability (from the center of the field outward) would be the prerequisites for the relative localization in the coronal plane, i. e., for the localization of objects relative to each other and for the correct estimation of the distance between them in the coronal plane. This implies merely that the visual substrate must be so organized that a given distance in one part of the field of vision should be perceived as equal to an objective distance of the same length exposed in any other part of the field of vision.[61] Wherever the gradients of excitability are irregular

59. As stated before, these deductions imply that the spatial projection of the retina onto the striate cortex has some functional significance.

60. In our series, disturbances in fixation were noted only in cases of severe spatial disorientation. Whether or not all disorders in visual space perception (of cerebral origin) are accompanied with changes in the mechanisms of fixation could not be determined in the absence of ophthalmographic equipment. However, abnormal torsion movements of the eyes and a characteristic tilting of the head, and even of the entire upper part of the body, were noted in several patients with lesions of the occipital lobe during perimetric examination (cf. Goldstein's "preferred position").[17b] These patients had various forms of homonymous amblyopia in certain regions of their field, with resulting distortion in visual space perception and other perceptual functions.

61. This principle is, indeed, realized within certain limits; normal visual space has metrics which approximate the structure of euclidean space (the ideal space

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(e. g., considerably steeper in one particular quadrant), owing to a local circumscribed defect, there may occur a corresponding distortion of perceived linear dimensions in that part of the field. A given distance in the coronal plane will be perceived differently in different parts of the field; in addition, there may be illusory curving of lines and similar deformations of contour (dysmorphopsia), as was actually found in our cases.

The vector-field theory of localization in visual space might therefore be translated (at least so far as the coronal plane is concerned) into a theory of differential excitability in the projection areas. However, the actual conditions in the organism are undoubtedly more complex, since the connection between the macular area and the "subjective framework" of the field is functional and relative. During voluntary ocular movements, the absolute localization of perceived objects in space is practically maintained. The functional coordinates of the field keep their identity, in spite of the fact that different retinal areas are stimulated in rapid succession. The physiologic substrate of orientation in the coronal plane cannot, therefore, be a simple static pattern of excitability. A more likely assumption is that of a patterned background activity (an active "patterning") which determines the different gradients of excitability in the different sectors of the projection area.[62]

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constructed in everyday geometry). However, even in normal visual space, certain definite deviations from euclidean structure can be observed during the act of perception. These deviations are indicative of the fact that the metric structure of visual space is "dynamic," and never absolute. (*a*) A space filled with perceived figures seems longer than unfilled (homogeneous) space; (*b*) a given distance perceived in the periphery seems slightly curved and shorter than the same distance when seen in the center of the field; (*c*) vertical extensions tend to appear longer than horizontal extensions. In other words, even normal visual space is not strictly identical with the space of euclidean geometry. It is "anisotropic" or has different degrees of density or curvature in different parts of the field.

The concept of curved spaces is familiar to the modern physicist who deals with riemannian geometry. But such spaces cannot be visualized unless they are interpreted in analogy to fields of force. Forces can be irregularly distributed in a given field, such as an electromagnetic or a gravitational field. The physicist then assumes that the characteristics of any given space depend on the particular distribution of these field forces or vice versa. Field forces, obviously, are constructs, and are never directly observed. This does not reduce their usefulness for explanatory purposes. The physicist observes that in proximity to a large body light rays are bent. He then infers either that light rays can be distorted by gravitational force or that the space in the neighborhood of the large body is curved. Either expression has certain advantages for the development of mathematical models of the situation.

62. Possibly the simple assumption of a distortion in spatial cerebral gradients in excitability will have to be replaced by a more complicated conception of disturbances in temporal patterning of processes which normally take place synchronously in a multiplicity of cortical units. In the defective sector, excitation may turn

Such background activity may be imputed to the visual areas themselves or, according to Lashley,[63] to an intervening system which mediates the direction factors supplied by the visual apparatus and the complex patterning of postural and motor adjustments.

The existence of such an intervening system is not negated by the application of a vector-field theory. On the contrary, it seems to us that the field theory alone is sufficiently neutral to allow for an adequate consideration of all the facts (particularly those deriving from the interrelation of cerebral regions, such as the postural and visual systems). The phenomena of normal and abnormal space perception suggest that the field theory in its present form should be retained until its heuristic functions are fulfilled and the underlying cerebral determinants of perception identified.

A final note should be added concerning the question of localization of function. Our observations might lead to the conclusion that circumscribed lesions of the right parieto-occipital region tend to produce disorders in the spatial organization of visual perceptions. However, such a conclusion is unwarranted. All injuries in our series of cases were produced by bullet or shrapnel. The cerebral damage which results from such missiles, traveling at velocities high enough to penetrate the cranium, is far more generalized and widespread than the intracranial path of the metallic fragments would seem to indicate.

It would be premature, therefore, to make any statement concerning the minimum extent of damage sufficient to produce these symptoms. The 2 cases selected for this report illustrate how practically identical disorders in peripheral function could be observed in a hemiparetic patient (with seemingly intact fields of vision) and in a patient with a normal neurologic status (except for a minor quadrantic field defect). It should be obvious that the investigation of systematic variations in basic perceptual functions, such as space perception, has to precede any attempt to define their possible structural correlates.

SUMMARY

Disorders in the spatial organization of visual perceptions were found in 12 patients with cerebral lesions in the parietal and occipital regions.

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out to take more time to reach its maximum, or else the cycle of recovery may be interfered with as a result of the trauma. These arguments may be strengthened if one considers the nature of the perceptual disturbance in cases in our series in which teleopsia was less prominent. In many of these cases the patient reported (monocular) diplopia and recurrent polyopia in the most implicated regions (Bender, M. B.: Polyopia and Monocular Diplopia of Cerebral Origin, Arch. Neurol. & Psychiat. **54**:323 [Nov.-Dec.] 1945. Bender and Teuber [48a]). There were also various forms of illusory motion. Possibly these symptoms, viz., illusory motions, reduplications and abnormal depth of images, form a continuum. They may represent a series of perceptual responses to various degrees of one and the same fundamental alteration in cortical functioning.

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In some of these patients (selected from a large series of patients with wounds of the brain incurred in battle) the disturbance was limited to homonymous quadrants of the visual fields and was most pronounced in circumscribed sectors of these quadrants. In these areas the patients were unable to localize (visually) any stationary (and sometimes moving) object in all three dimensions of space. The 2 patients whose cases are reported in detail showed such errors in localization, predominantly in the sagittal plane. Both showed varying amounts of teleopsia. With the teleopsia, there were concomitant changes in apparent size and brightness. The phenomena appeared with binocular vision as well as with monocular vision with either eye.

Direction and extent of apparent displacements of objects perceived in the involved regions of the field of vision were consistent and characteristic for each patient. On the other hand, the disturbances did not assume an all or none character. The apparent displacements were increased by prolongation of exposure, and they were minimized or abolished on tachistoscopic study. Under certain conditions a complete "reversal" of the abnormal depth effect could be observed, so that persistent teleopsia changed momentarily into "pelopsia" (or the illusion of abnormal nearness).

In order to get at the functional correlates of these alterations in space perception, a methodical sampling of perceptual and/or motor performances was undertaken. (The special tests and procedures employed are described in the body of these reports and in previous publications). As a result of these tests, it is concluded that the alterations were not produced by a general reduction in "cognitive ability" or any similarly defined intellectual functions, but by systematic changes in function which had taken place in the most implicated quadrants or half-fields. The implicated quadrants and half-fields seemed "weakened" as compared with the less affected regions of the same field of vision or with corresponding areas in the fields of normal controls. It is pointed out that none of the usually accepted theories of space perception can explain why such generalized "weakening" should be associated with an apparent dropping back of perceived objects in space. Evidently, the patients behaved as though the subjective coordinates of their visual space had been permanently altered. It is submitted that such a change can be best described, even though not explained, in terms of a field theory of visual perception.

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63. Lashley, K. S.: The Problem of Cerebral Organization in Vision, Biol. Symposia **7**:301, 1942.

Special Articles

ONE HUNDRED YEARS OF PROGRESS IN NEUROLOGY, PSYCHIATRY AND NEUROSURGERY

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ONE HUNDRED years ago our world was in a good deal of turmoil. The governments of France and Germany were busy repressing revolutionary movements. Great Britain was thriving under Victoria but fighting the Punjab Wars. In America there was an intellectual drive that reached its height in what Van Wyck Brooks has called the "Flowering of New England." The United States Army was invading Mexico.

The people of our Western civilization were religious. Questions of scripture, sect and creed were of great importance in the lives of most educated men and women. Reformers and idealists flourished. The tolerant liberal was not part of the scene. Customs and dress were formal, among the educated. There was a wide gap between social strata, and class feeling was strong. From the locomotor standpoint the world was still equine, as it had been for three thousand years. People talked horse, thought horse and lived with horses intimately. Railroads were beginning to draw the world together and fire the imagination of those who were soon to produce the machine age.

In the field of medicine specialization was just appearing. In most university medical schools, even in Germany, the professor of medicine taught almost everything clinical. For example, at Rostock in 1848 one professor gave lectures on clinical medicine, surgery, ophthalmology and obstetrics. In Vienna a separate university clinic for surgery was first established in 1849. Pathology was just coming into its majority; Rokitansky was the first full professor of pathologic anatomy, separated from anatomy; he was appointed in 1844. Virchow was given a professorship in pathology in 1849. The year previous he had started his famous *Virchows Archiv* and launched cellular pathology on its meteoric course. Pasteur was starting his work on ferments. Claude Bernard was studying the physiology of the pancreas. Surgical anesthesia was rapidly spreading its blessings and making it possible for surgery to become a thoughtful discipline instead of an almost acrobatic *tour de force.*

As for our special concern—neuropsychiatry—the year 1847 was not obviously of any special import. True, the whole direction of medicine

This paper was the Centennial Address given before the Section on Nervous and Mental Diseases at the Ninety-Sixth Annual Session of the American Medical Association, Atlantic City, N. J., June 12, 1947.

was changing, and this was to influence profoundly the specialties concerned with the nervous system, but nothing made this year epochal. Psychiatry was well under way and progressing rapidly as a specialty.[1] In 1847 there were over one hundred special hospitals or wards for the mentally ill, twenty-nine of them in America (not counting the many private homes that took in a few patients). Some of these hospitals were well planned for psychiatric care, and some of the superintendents were men with profound interest in psychiatry. In fact, in 1841 the British Medico-Psychological Association was formed, and in 1846 the American Psychiatric Association was founded by thirteen hospital physicians. Dorothea Dix was ardently campaigning to get the mentally ill out of the jails and almshouses and into special mental hospitals. Pinel and Tuke had done this in France and England fifty years before, with some local success. The rise of interest in psychiatry in the 1840's is perhaps best emphasized by the fact that three journals on this subject were started in England, France and America.

Neurology as a clinical discipline was represented by one man, Romberg, in Berlin,[2] who had recently published a textbook. Duchenne de Boulogne was active in Paris, but had as yet received little recognition. Up to this time the contributions to neurology had been made by anatomists, physiologists and general medical men. As a specialty it was just appearing.

Neurosurgery in 1847 did not exist.

Before considering the century of progress in neuropsychiatry, one must sketch in the background of advance in general medicine. It would indeed be meaningless to try to sketch progress in a specialty without constant reference to the main stream of medical development. Figure 1 is a diagram constructed to show the main advances in medicine, indicated as steps and plotted on an abscissa of the years from 1847 to 1947. The steps are blocked in to show the beginning of a subject and how each supports the mass of accumulating medical knowledge. Accuracy is not possible on such a chart; it serves only to give a general background.[3] Nevertheless, several interesting things appear. It is obvious that the five years from 1845 to 1849 were great years for advance in physiology and pathology. Ludwig and Virchow were coming into eminent positions. Of course, physiology, pathology and

1. One Hundred Years of American Psychiatry, American Psychiatric Association, New York, Columbia University Press, 1944. Zilboorg, G., and Henry, G. W.: History of Medical Psychology, New York, W. W. Norton & Company, Inc., 1941.

2. Viets, H.: Neurology—Past and Present, J. A. M. A. **109**:399 (Aug. 7) 1937.

3. Garrison, F. H.: Introduction to the History of Medicine, ed. 3, Philadelphia, W. B. Saunders Company, 1924.

chemistry each has a long history before 1847. The discovery of surgical anesthesia came like a great revivifying stimulus to surgery, allowing an operation to be a careful procedure, not a race with pain. Into the years between 1855 and 1875 are crowded extraordinary advances in bacteriolgy, antisepsis, cellular pathology, organic chemistry and the beginning of immunology. Also, there are the improved technics in trained nursing and antiseptic surgery. Truly, a marvelous twenty years!

After this comes another twenty years, during which the microbe held sway. The organism responsible for disease after disease was being discovered. Cleanliness and public health became accepted ideas. It looked as if all disease would turn out to be microbic, and most physicians

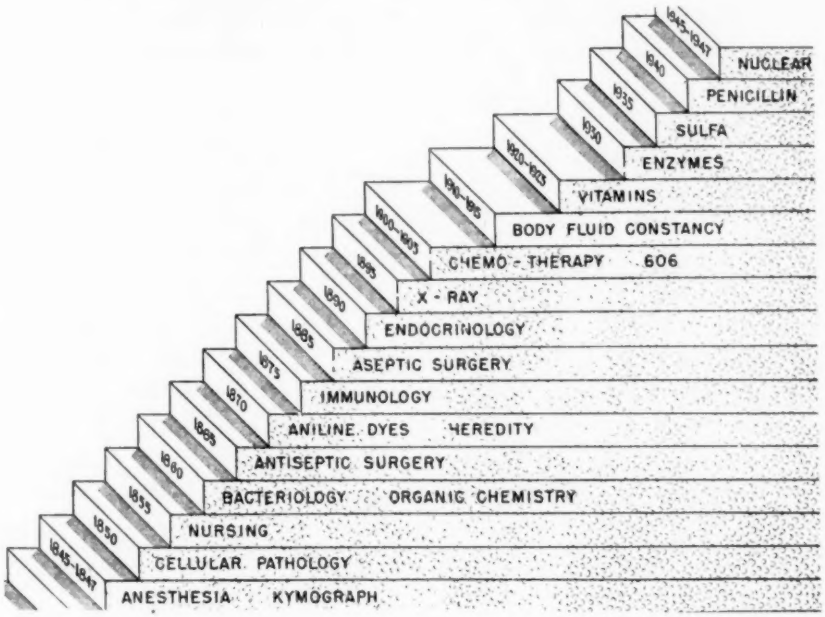

Fig. 1.—Diagram indicating the main steps of medical progress between 1847 and 1947. The years are shown on the face of the riser of each step. The main medical advance of that year is shown on the block that makes the step. These blocks, piled one on another, show the cumulative advance in medical knowledge through the century. The latest advance is indicated with the word "nuclear" on the top step, meaning nuclear physics and the various recent developments in medicine rising from that new knowledge. The whole diagram is used to show the medical background of the last hundred years on which one might impose the advances in psychiatry, neurology and neurosurgery.

were beginning to think so. Then, at about the beginning of the new century, a change occurred; physics and chemistry began to produce facts with a great bearing on medicine. Roentgen gave the x-ray to medicine, not only to photograph the bones and viscera but to begin the understanding of radiation and atomic structure. Chemotherapy came in with acetylsalicylic acid and neoarsphenamine; later there were the sulfonamide drugs. But the most significant change was the growing

realization that many diseases are due not to invading organisms but to disordered function. Endocrinology came in, with the teaching of the hyperfunction and hypofunction of glands. Chemical deficiencies in vitamins and fluids and electrolytes began to be understood. Great advances in the treatment of chronic disease followed.

Of course, another chart should be made showing the dependence of these medical advances on the historical background of biology, chemistry and physics. These sciences prepared the minds of thousands and made possible the crucial observations of a few. Besides, there were the great schools of physics at Cambridge, and of Müller in Germany, with his various students, like DuBois-Reymond, Ludwig, Henle and Virchow. These laid the foundations, but the study of these origins takes us too far afield, and the reader is referred to Dampier's "History of Science" [4] and to Cohn's "Research in the Medical Sciences." [5]

SYPHILIS

In this year 1947 a minority of psychiatric patients have discoverable cerebral lesions which can be correlated with their mental symptoms. Yet this minority forms an important group, giving to psychiatry its main contact with neurology. Much has been learned from the personality disorders arising from cerebral lesions—tumors, degeneration, inflammation and trauma. Here, symptoms have led to an understanding of normal and abnormal function in the light of autopsy observations. Of great importance to the development of psychiatry has been the unfolding of the story of neurosyphilis.[1] At first there was confusion. Conditions in mental hospitals were so bad that no good clinical observations could be made. With the improvement of hospital care, syndromes could be seen and classification became possible. An early clinical concept was "general paralysis of the insane." Later it was separated clinically from tabes and, finally, from vascular neurosyphilis. Gross lesions were early recognized, but the histologic picture was not clearly drawn until cellular histology had been developed for sixty years. It took about eighty years to move from the suspicion that the disease was syphilitic to proof of the fact. Throughout all this time the study of neurosyphilis was a great stimulus to psychiatric thinking. The *dénouement* early in this century was an even greater stimulus, for here was a proved example of a mental disease with a known cause, a typical lesion and a specific treatment.

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4. Dampier, W. C.: A History of Science, London, Cambridge University Press, 1944.

5. Cohn, E. J.: Research in the Medical Sciences, in Medicine Today: March of Medicine 1946, New York, Columbia University Press, 1947.

The principal characters in this story are shown in the accompanying table.

Chronology in Neurosyphilis

1820	Clinical descriptions	
1826	"Paresis" established as an entity	Bayle
1841	Chronic, diffuse periencephalomeningitis	Calmeil
1846	Tabes described	Romberg
1850	Unequal pupils noted	Baillarger
1857	Syphilis suggested as cause	Esmarch
1871	Knee jerks differentiated	Westphal
1875	Tabes considered syphilitic	Fournier
1894	Statistical proof of cause	Fournier
1897	Patients with dementia paralytica shown to be immune to reinfection	von Krafft-Ebing
1904	Histopathologic description	Alzheimer
1906	Wassermann test	
1910	Neoarsphenamine "salvarsan" discovered	Ehrlich
1912	Salvarsanized serum	Swift and Ellis
1913	Spirochete demonstrated in brains	Noguchi and Moore
1917	Fever therapy	Wagner–von Jauregg
1945	Penicillin therapy	

"General paralysis of the insane" was well described in the 1820's by several clinicians. Bayle, however, seems to have been the first to consider the disease an entity and to have related the symptom complex to the pathologic picture. His "Traité des maladies du cerveau et de ses membranes," published in Paris in 1826, emphasizes that this syndrome is not a complication or an end result of various forms of insanity. But French physicians disputed this concept for another thirty years. Salomon, in 1862, suggested the term "general paresis." Baillarger, in 1847, had divided patients with the disease into those with and those without mental symptoms, both having disordered motor function. It remained for Westphal to clear up the relationship of the clinical pictures of tabes dorsalis and dementia paralytica, although Romberg had published his classic description of tabes in 1846. It gradually became clearer that the two diseases could occur together, that usually they were not associated and that they had different sorts of motor disability.

As to the cause of dementia paralytica, many theories and speculations were expressed. Early in the nineteenth century "the strain of modern life" was blamed, as well as head injury, excessive mental work, alcohol and venery. Syphilis was not seriously considered as a cause until 1857. Fournier brought statistical data to bear on the subject in 1894, and in 1897 von Krafft-Ebing showed that inoculation of patients who had dementia paralytica with fresh syphilitic virus produced none of the expected secondary symptoms. The Wassermann test, developed in 1906, clinched the matter by showing that over 90 per cent of patients with the disease had "positive" reactions. If any doubters remained after this, they had to accept Noguchi and Moore's discovery of the spirochete within the brain in 1913.

Treatment with mercury and iodides had been tried for years and found wanting. In fact, failure of this method had been used as an

argument against the syphilitic origin of the disease. Neoarsphenamine was tried soon after its discovery, in 1910, and the new arsenicals were tried both intravenously and intrathecally by the Swift-Ellis method. In 1917 Wagner von Jauregg introduced malarial therapy. Later, improved arsenicals, bismuth compounds, fever treatment with malaria and physical hyperthermia greatly enhanced the efficacy of therapy. At the present writing it looks as though penicillin may shove most of these methods into the discard.

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During the past hundred years there has been a steady accumulation of facts concerning motor and sensory function of the nervous system of man and of laboratory animals.[7] At the beginning of our century of psychiatry von Helmholtz (1850) measured the speed of nerve conduction and described reaction time. This was the start. The idea that physicochemical processes in nerve tissue could be measured was set on a sound basis. Soon Fechner (1860) was able to make laws for psychophysics, such as the quantitative relation of sensory response to stimulus. By 1879, when Wundt's laboratory was established, the study of experimental psychology was well under way and it progressed steadily. Not only Ziehen was optimistic, but the authoritative Kraepelin promoted experimental psychology as a fundamental basis for psychiatry until the 1920's. Something, however, was wrong. It began to be apparent that these hopes were not being fulfilled. It was said that sensation-psychology and association-psychology would never explain mental processes. It became clear that what psychiatry needed was an understanding of thought processes, normal and abnormal. The simplifications of those who tried to look on mental processes as nothing more than the working of sensations on a hierarchy of reflexes, even conditioned reflexes, were found wanting. As far as psychiatry was concerned, eighty years' work of the academic psychologists had produced nothing useful.

Two other schools of psychology have arisen in the recent past and given hope of aiding psychiatry: behaviorism and gestaltism. Behaviorism arose as a cult in 1913 and leaned heavily for support on Pavlov's

6. Ziehen, T.: Oration on Installation as Professor of Psychiatry, Utrecht, Oct. 10, 1900, Jena, Gustav Fischer, 1900.

7. Moore, T. V.: Psychology and Psychiatry, in One Hundred Years of American Psychiatry, New York, Columbia University Press, 1944, pp. 443-479.

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Gestalt (configurational) psychology began with Ehrenfels, in 1890. The theory that perceptions were made up of combinations of many sensory stimuli was controverted. Objects were shown to be perceived as a whole, and relationships were shown to be more important than absolute values. An animal trained to react to the darker of two shades of gray would still react to the darker of a pair when the scale was changed and the shade to which he formerly reacted was made the lighter of the pair. Innumerable experiments on animals and man by Wertheimer, Koffka and Köhler proved that the total sensory impression, its relationships or configurations, was the stimulus to which the animal reacted. This concept is certainly a great advance over the sensationalist psychology it supplanted. Its contribution to psychiatry, however, is not great. It has at least tended to make psychiatrists more responsive to the holistic conception of personality, and it has thrown light on the learning process, which is too often neglected in psychiatry.

Another line of experimental work, which has proved more fruitful in influencing psychiatry, is that of the physiologists who worked on the nervous system. Mosso [8] was one of the earlier observers. For the last fifty years Sherrington has been steadily producing papers on the integration of the nervous system that have given us a new point of view concerning reflex action, inhibition, facilitation and cerebral function. The idea of integration has become so universally accepted as important that one does not realize that the concept comes largely from Sherrington.[9] It gives clearer understanding, whether one is studying modern electromyograms of spinal reflexes or the disintegrated ego of a neurotic patient.

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10. Gantt, W. H.: Experimental Basis for Neurotic Behavior, New York, Paul B. Hoeber, Inc., 1944.

11. Freud, S.: New Introductory Lectures on Psychoanalysis, New York, W. W. Norton, 1933, lecture 31.

12. Meyer, A.: Role of Mental Factors in Psychiatry, Am. J. Insanity **65**:39, 1908.

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13. Thorndike, E. L.: Man and His Works, Cambridge, Mass., Harvard University Press, 1943.

works back on the $S \rightarrow R$ connection and makes it likelier to happen again. The fact that the reaction causes satisfaction reenforces and confirms the reaction itself. Thus, confirming reactions play a great part in signaling back "correct" or "well done" to the sensorimotor connections. This increases speed in the learning of skills. The confirming reaction is a kind of reward, and a man can change his mode of reaction "by the influence of his own confirmation on connections whose consequences satisfy him." In other words, here is experimental evidence for believing in the psychologic effectiveness of man's self direction toward a goal. One educates himself along lines that give him satisfaction; one thus seems to be partly responsible for the good or bad result. This is an important mental mechanism, and should be considered a great contribution to dynamic psychology. Much recent work on the learning process has elaborated and modified it, but the principle stands.

Dynamic psychology attempts to explain *why* people behave the way they do. It takes into consideration such complex mental situations as conflicts, rewards and punishments, emotional drives and needs, inborn behavior patterns, reflex conditioning and cultural education.

It is this sort of study of the personality, whether it be by the long psychoanalytic method or by shorter technics, that allows the physician to learn what sort of a person it is who has the symptoms he hopes to alleviate. It is important to understand the person whether the main cause of disorder seems to be tumor, trauma, inflammation or emotions.[14] Psychosomatic medicine, in the best sense, is sound, comprehensive medicine with a pluralistic concept of etiology and a multiple therapeutic attack. The great advances since 1900 in neurophysiology, endocrinology, psychology and psychiatry have made this possible. The result is "dynamic," because it takes in the living relationships between persons, the drives and urges of the individual organism, the resulting emotions and their effect on behavior. Psychosomatic disorders are the most obvious examples, but the whole field of psychiatry and of medicine is involved.

Such revolutionary theories and procedures as those of Freud do not come on the world suddenly. The havoc wreaked on man's soul and body by the concatenations of fate has been the subject of poets and story tellers for ages. The Greeks drew tragic nets about their heroes; situations forced them to commit acts for which they suffered mentally and physically. To the archaic mind, gods, demons and prophets were responsible. Two thousand years later Shakespeare saw the play of human passions more subtly. He described their effects on the fortunes and bodies of his characters, but still dragged in a bit of demonology. The sixteenth century saw the beginning of the

14. Hunt, J. M.: Personality and the Behavior Disorders: A Handbook Based on Experimental and Clinical Research, New York, The Ronald Press Co., 1944.

modern era; people began to think more as they do today. Their books and plays are more comprehensible. The good ones show an intuitive understanding of psychologic dynamics.

Between 1450 and 1850 the occasional appearance of a great clinician advanced medicine. In general this was a slow and well rounded development, with plenty of human understanding to complement the technical advances. Just before 1847 there seemed to be many physicians who understood the patient as a person. Ideas that would now be called "psychosomatic" began to be expressed in writing. For example, Amariah Brigham wrote in 1835 that dyspepsia was primarily a disease of the brain. Von Feuchtersleben wrote "Zur Diatetik der Seele" in 1838. Descuret's "Médecine des passion" (Paris, Labe, 1841) shows that he knew a great deal about the effect of emotions on symptoms. Sweetser, in 1843, brought out a remarkable book entitled "Mental Hygiene," which discussed many psychosomatic problems. Hypnosis was being studied and used in therapy and for surgical anesthesia; Braid had just rescued it from the cult of mesmerism and animal magnetism.

In the next fifty years, however, the great light shed on medicine by Virchow, in cellular pathology, and Pasteur and Koch, in bacteriology, cast its shadow on psychology. The advancing majority of physicians were convinced that all diseases would be explained by application of the microscope. Except for a few voices, well drowned out by the wave of histopathologic enthusiasm, little was heard of psychology or the possibility that what one thought or felt might affect medical symptoms.

The dynamic psychology of today can be traced back to several lines of thought, dimmed between 1847 and 1900, but emerging slowly as the end of the century approached. Hughlings Jackson's discussions of "evolution" and "dissolution" of the nervous system may come closer to Sherrington's "integration" and Freud's "regressions" than is usually supposed.

The psychologic precursors of Freud and Meyer are less clear. But those who worked with hypnotism and thought about the effects of suggestion and emotions on the body were certainly keeping the torch burning for the enlightenment that began as the twentieth century opened. "Few were rash enough to challenge the reign of the microbe," as Galdston [15] put it. In France, Liebeault kept the clinic going at Nancy, where hypnosis was a practical procedure. Bramwell and Tuke kept up interest in England. Oliver Wendell Holmes,[16]

15. Galdston, I.: Modern Attitudes in Psychiatry, in Medicine Today: The March of Medicine, New York Academy of Medicine, Lectures to the Laity, New York, Columbia University Press, 1945.

16. Psychiatric Novels of Oliver Wendell Holmes, abridgement, introduction and annotations by C. P. Oberndorf, New York, Columbia University Press, 1943.

from 1859 to 1885, was writing his "medicated novels," which showed much insight into personality problems and forecast some of Freud's contributions. Rosenbach,[17] in the eighties and nineties, fought against the domination of cellular pathology "to obtain a broad view of the realm of energetics . . . and of the total balance of phrenoromantic activity." Putnam [18] lectured on "Not the Disease Only But Also the Man." Charcot created the school of "grand hypnotism" in Paris, which led directly to the psychologic advances of Janet and Freud.

The academic psychologists, from Wundt to Watson, had failed to make any significant contribution to the knowledge of human nature. Psychiatry needed greatly to be brought out of its stalemate in systematization by some knowledge of human emotions and motivations.

One should not underestimate the important work of Kraepelin. He is largely responsible for bringing order out of chaos in clinical psychiatry. But his classification became fixed. Syndromes were looked on as diseases. Syphilis was the paradigm. This authoritative systematization was jokingly called "imperial German psychiatry" by its adversaries.

To relieve this situation, it was necessary for psychiatry to gain an understanding of social relations, personal motivations and emotions. Darwin,[19] in 1873, had described emotional reactions as important biologic phenomena; Mosso had made measurements of changes related to emotional states. It was Cannon, however, who seriously took up the problem of the physiology of the emotions. He made it a profound and respected study and published two important books,[20] which showed the way for the many clinical studies that immediately followed. "Psychosomatic medicine" [21] was born rather precipitously

17. Morrison, H.: Ottmar Rosenbach, Pioneer in the Development of the Concept of Functional Disease and Functional Diagnosis in Internal Medicine, Ann. Int. Med. **11**:527, 1937.

18. Putnam, J. J.: Not the Disease Only But Also the Man, Boston M. & S. J. **141**:53, 1899.

19. Darwin, C.: Expression of Emotions in Man and Animals, New York, D. Appleton and Company, 1873.

20. Cannon, W. B.: Bodily Changes in Pain, Hunger, Fear and Rage, New York, D. Appleton and Company, 1929; Wisdom of the Body, New York, W. W. Norton & Company, Inc., 1932.

21. The term "psychosomatic" was used by Draper to designate this field in 1928. Cornell had used the term "somatopsychic" as early as 1909, but with a somewhat different connotation. Although the term is new, the idea is old. Temkin has pointed out (Bull. Hist. Med. **16**:519, 1944) that the old platonic doctrine of the tripartite soul teaches unity of body and mind. Modern "psychosomatic" medicine can be looked on as a reaction against the laboratory teaching of the last half of the nineteenth century. Down to the early nineteenth century there was a large psychosomatic element in medical thought, probably fostered toward the end by the German romantic period.

and is still a precocious infant. It was conceived by the coming together of three fertile schools of thought—the physiology of the emotions, psychoanalysis and psychobiology (fig. 2).

Freud published his first psychoanalytic papers in the nineties. But there was much local opposition to Freud's views, and the theories were not spread abroad for ten or twelve years. Bleuler and Jung joined the work in the early years, bringing the concepts to Germany and Switzerland. In America Freud lectured in 1909, where Putnam, Brill and White were already spreading psychoanalytic ideas. In the beginning Freud worked on the symptom; then he brought out the theory of the unconscious and repression. This led to a study of the instincts and sexuality. The libido theory emerged, and finally the psychology of the ego. For those concerned with humanity, interpersonal relations and motivations, here was a set of postulates with which to work. The

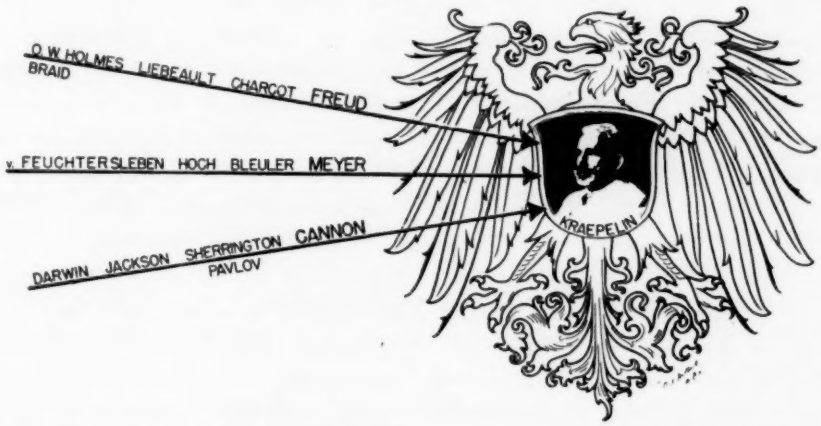

Fig. 2.—Diagram showing Kraepelin as the exponent of systematization in psychiatry. This is placed on the eagle because his psychiatry has been called the "imperial German psychiatry." During the last forty years there has been an increasing dissatisfaction with Kraepelin's point of view, which has been opposed by the freudians, by Adolf Meyer and (tacitly) by the physiologists, such as Cannon, who have shown the importance of emotions in the physiology of the human organism.

first world war somewhat inhibited the spread of psychoanalytic studies, but in the period between the wars the development was rapid and widespread until, at the time of Freud's death, in 1939, many institutes for the training of psychoanalysts in Europe and America had been founded. Publications on the subject had swelled to a volume beyond the capacity of one person to read. Since Freud's death there has been a tendency toward less "orthodoxy"; his influence still grows, although his views are being modified and new clinical methods are appearing.

The third school of thought was Adolf Meyer's psychobiology. This set of ideas developed largely between 1900 and 1915. It was certainly influenced by Freud's ideas concerning the neuroses, but Meyer

was more concerned with the psychotic reactions. His concept of the personality behind the psychosis has permeated all modern psychiatric thought. No psychiatrist would now study a patient without trying to learn about his "prepsychotic personality." Meyer preached the necessity for gathering all pertinent facts about a patient and seeing not only the mental disorder in the patient, but the "he" or the "she" who is sick, in the setting of his or her life situation. The importance of psychogenesis was emphasized. Not alone as *the* cause of mental disorder, but as one factor to be carefully weighed. Facts concerning heredity, medical status, body build and any other relevant data were also considered. The treatment and prognosis were determined after adding up as completely as possible the patient's assets and liabilities. The diagnosis was thought of in terms of types of reaction.

Nowadays, when every educated person imbibes some of the concepts of psychogenesis and motivation in general reading, and when every medical student learns something about them in his early psychiatric studies, it does not seem possible that the field was a battleground so recently. Now that the battle has been won, it is hard to believe how well entrenched was Kraepelin and his systematic "imperial German psychiatry." The victory was due to the direct attacks of men like Meyer, Bleuler and Hoch; to advancing knowledge of the physiology of the emotions, and, most of all, to the genius of Freud.

MENTAL MEASUREMENT

Galton [22] was the first to concern himself especially with individual differences in intellectual qualities. In the early growth of experimental psychology, the work of Cattell [23] united Galton's influence with that of Wundt. The earliest important influence on psychiatry seems to have come through Kraepelin. These sources developed a methodology for the study of intellectual processes with which much of today's accomplishment might have been possible. But it was inhibited by two factors. One was an overconcern with sensory-motor functions, derived from the early influence of physiology. The other was an unreadiness to bring the so-called higher mental processes under a unifying concept, like "intelligence." Making this unification was Binet's contribution, and it was of incalculable value in getting people to think systematically about individual differences in the intellectual field.

Binet's work [24] had been stimulated by the individual differences of school children. An analogous development in this country was the psychologic clinic founded by Witmer in 1897 [7] for the study of

22. Galton, F.: Psychometric Experiments, Brain **2**:149, 1879-1880.

23. Cattell, J. M.: Experiments on the Association of Ideas, Mind **12**:68, 1887.

24. Binet, A.: Etude expérimentale de l'intelligence, Paris, Schleicher frères & Cie, 1903.

school retardation, but the methods did not lend themselves to the broad uses of the Binet procedures. Shortly after the appearance of Binet's work, Goddard published an English adaptation; but the measurement of intellectual functions did not come into wide use until the publication of Terman's work in 1916.

The general field of clinical psychology was thus at first related to educational problems and children. The object was to learn what the normal child could do, year by year, as he developed. As a necessary by-product, it was learned that certain children could not do what was normally expected. They were the defective personalities, and came into the realm of psychiatry. The old term "idiot" was soon broken down into meaningful levels of defectiveness, such as idiot, imbecile, moron and dull normal intelligence. Rough though this quantitative system was, it was seen to be valid and practical. The psychiatrists were immediately interested and took over the methods for use in clinics where behavior problems of children were studied, or where grading of adult intelligence was important, as in psychiatric diagnosis and the determination of legal responsibility. Methods were refined, and by 1917, when great armies were amassed, methods of mental testing based on somewhat different principles were applied on a large scale.

By far the greater share of testing now done is of this group, or mass, variety; and it has led to technical and conceptual developments, such as factor analysis. Among the more advanced clinical thinkers, also, there has been a tendency to break away from global concepts like intelligence and to resolve them into components not unlike the "factors."

With the further development of special technics, psychologists have become essential in schools, in jurisprudence, in industry and in the social sciences. The psychiatrist usually has little training in this field, but certain ones by special study have gained competence and given to clinical psychology the experience of psychiatry and medicine. This has been all to the good. Some disagreement and strife, however, resulted from a feeling that the workers involved were invading each other's private domains. The recent development of work teams has gone far to dispel this attitude. Now psychologists are appointed to hospital positions and join with social workers and physicians in arranging proper treatment for patients. Some psychiatrists have also been taken into academic faculties to serve in departments devoted to the social sciences.

The determination of intelligence level has long ceased to be the main aim of the clinical psychologist. He is usually equipped to study special capacities and emotional reactions, as well as preoccupations and fantasies. In the broader fields, the "projective tests," especially that devised by Rorschach, have been invaluable. The employment of stimuli, like the ink blots, allowed the subject to give a clue to his fantasy

life and a picture of his approach to problems. Many useful variations of Rorschach's original technic, published in 1921, have now been made. This field of study is helping greatly in the understanding of "personality." In fact, the goal of a great number of investigators in medicine, psychology, anthropology, business administration—and eventually in all human endeavor—is to understand personality. In Pope's phrase: "The proper study of mankind is man."

VITAMINS AND CHEMISTRY OF THE NERVOUS SYSTEM

Just as the microscopists optimistically believed that mental disease would eventually be explained on the basis of cerebral histopathology, so the chemists had their hopes. Perhaps it would be fairer to say that some psychiatrists who knew little of chemistry pinned their hopes on it without adequate cause. Nevertheless, some work was done. Folin explored the field, and his negative results were of value in orienting research. Recent work makes one all the more sure that psychiatry will benefit greatly from studies on the chemistry of nerve tissue. Reviews by Page [25] and Folch [26] show ways along which research may go. Up to the present, however, little relation can be seen between the known chemical reactions of nervous tissue and mental symptoms. In one direction, however, the search has been specifically fruitful. Chemistry has been of immediate and direct importance in the field of nutrition.

The word "vitamin" was introduced by Funk in 1911 [27] to describe the cause of beriberi. Eijkman,[28] as early as 1897, produced neuritis in chickens and showed that a specific nutrient could alleviate a known deficiency. It was twenty years, however, before the relationship of vitamins and enzymes to cerebral metabolism began to be understood. That vitamins are part of the structure of many enzymes is now understood. That both are necessary to cerebral metabolism is established. The group of vitamins necessary for the prevention of degenerative changes in the nervous system are thiamine, nicotinic acid, riboflavin, pantothenic acid and pyridoxine. Lack of vitamins A and D have secondary effects on the nervous system. The study of the vitamin B group comes down to an understanding of the processes involved in the utilization of carbohydrates in the brain, a most fundamental consideration for those who would study cerebral function. That this is

25. Page, I. H.: Chemistry of the Brain, Springfield, Ill., Charles C Thomas, Publisher, 1937.

26. Folch, J., in Psychiatric Research, Cambridge, Mass., Harvard University Press, 1947.

27. Funk, C.: Chemical Nature of the Substance Which Cures Polyneuritis in Birds Induced by a Diet of Polished Rice, J. Physiol. **43**:395, 1911.

28. Eijkman, C.: Virchows Arch. f. path. Anat. **148**:523, 1897.

a practical and important study is shown by the mass of work reported at the meeting of the Association for Research in Nervous and Mental Disease [29] in December 1941.

The number of patients concerned is large, much larger than most physicians realize. Most of us see a rare case of pellagra in the hospital, and an even rarer case of the Wernicke or the Korsakoff syndrome. These are interesting, but not numerically important. It is the great group of persons who have borderline states of nutritive failure that is important. These persons suffer from inertia, fatigue and nervousness of various types, so that they are said to have "neurasthenia"; but hundreds of them have been quickly relieved of symptoms by appropriate vitamin therapy. Among the aged, also, a great deal of mental disorder, mild and severe, has been ameliorated by vitamin therapy. This is a field at present concerned with only a small number of clinical entities, in which the psychiatric aspect is not always the most important. The deficiency diseases, however, affect a very large number of people. New angles to the problem are rapidly coming to light. A great many patients treated with the sulfonamide drugs suffer from mild or moderate states of confusion. This is apparently caused by the action of the drug on enzymes concerned in the cerebral oxidation of carbohydrate. It seems as though the chemistry of cerebral metabolism is just beginning to be understood. Continued study will have results far reaching in psychiatry.

SLEEP, STUPOR AND SHOCKS

In a case of insanity, where two scruples (of camphorated oil) were exhibited, it produced a fit, and a perfect cure followed. (Burrows,[30] 1828.)

Truly there is nothing new under the sun! The wonder is that old Dr. Burrows did not realize that he had made a therapeutic discovery. Had he taken it up and pursued it, convulsive therapy might now be a hundred and twenty years old. The reason he did not is probably the simple one, that psychiatry was not ready for such a discovery. It had to wait until the descriptive and systematic work was done that would allow for orderly therapeutic investigation. Little could be expected in an age in which all "insanities" were considered to be "melancholia," "mania" or "hypochondria" and no neuropathology was known. A hundred years later the stage seems to have been set for the great recent resurgence of treatment by chemical and physical agents. The events which led to this resurgence are not clearly connected; but, as I see it, the story runs like this:

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29. Cowgill, G. R.: Role of Nutritional Deficiency in Nervous and Mental Disease: Contributions of Physiological Investigations, A. Research Nerv. & Ment. Dis., Proc. **22**:3, 1941.

30. Burrows, G.: Commentaries on the Causes, Forms, Symptoms, and Treatment, Moral and Medical, of Insanity, London, Thomas & George Underwood, 1828.

In 1918 Professor Loevenhart [31] was studying the circulation of the blood in man, using cyanide preparations to stimulate respiration and employing passive insane patients as subjects. He and his collaborators noted that these patients improved after respiratory stimulation and seemed more in contact with the environment. Carbon dioxide [32] was also used as a respiratory stimulant, and patients were brought out of stupor for short periods of time. Thereafter, for ten years, these phenomena and the effect of narcotics, such as amytal, were thoroughly studied at the Wisconsin Psychiatric Institute. Much interest was aroused, and work was carried on in other psychiatric centers. It was noted that patients given carbon dioxide to the point of convulsion did well from the therapeutic standpoint.[33] Of great importance was the observation that patients undergoing the induction of amytal [34] narcosis went through a period of talkativeness in which psychologic data could be obtained and suggestions made. "In vino veritas" is a saying centuries old, but until 1932 no systematic and controlled study had been made of this behavior. In civil practice amytal narcoanalysis was tried out rather extensively between 1932 and 1935. In a few cases it was useful, but on the whole it did not help therapy much. It was not until the recent war that the method was taken up again, found useful with the acute neuroses of war and used extensively.[35]

Of course, the use of heavy doses of narcotics for psychotic patients was no new treatment. For years ether, chloroform and opium had been used. Griesinger had had some success in 1845, and Wolf had used "trional" (sulfonethylmethane N.F.) in 1901. But it was Klaesi, in 1920, who really thoroughly studied and tried out *Dauer-Narkose* on a large number of selected patients. He used "somnifene" (diethyl-diallyl-barbiturate of diethylamine); later "dial" (5-5-diallylbarbituric acid), phenobarbital and scopolamine were tried, in various combinations. Prolonged narcosis is still in use, although it is difficult to carry out, and the subject needs close watching and excellent nursing care. Many psychotic patients are benefited.[36]

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31. Loevenhart, A. S., and others: Sodium Cyanid and Respiration, Arch. Int. Med. **21**:109 (Jan.) 1918.

32. Loevenhart, A. S.; Lorenz, W. F., and Waters, R. M.: Cerebral Stimulation, J. A. M. A. **92**:880 (March 16) 1929.

33. Solomon, H. C.; Kaufman, M. R., and d'Elseaux, F.: Some Effects of Inhalation of CO_2 and O_2 and of Intravenous Sodium Amytal on Certain Neuropsychiatric Conditions, Am. J. Psychiat. **10**:761, 1931.

34. Lindemann, E.: Psychological Changes in Normal and Abnormal Individuals Under the Influence of Sodium Amytal, Am. J. Psychiat. **11**:1083, 1932.

35. Sargant, W. W., and Slater, E.: An Introduction to Physical Methods of Treatment in Psychiatry, Edinburgh, E. & S. Livingstone, 1944. Grinker, R. R., and Spiegel, J. P.: War Neuroses, Philadelphia, The Blakiston Company, 1945.

36. Palmer, H. D., and Paine, A. L.: Prolonged Narcosis as Therapy in the Psychoses, Am. J. Psychiat. **12**: 143, 1932.

Other chemical agents were tried empirically, among them insulin. Good results in schizophrenic patients were first reported by Sakel,[37] in Vienna, in November 1934. The practice of insulin shock therapy rapidly spread throughout Europe and America. Independently, and not empirically, but on the theory that epilepsy and schizophrenia were incompatible diseases and that, therefore, fits ought to cure schizophrenia, Meduna introduced camphor and metrazol [38] in the treatment of psychoses. As the experience with these chemical methods increased, it became evident that those patients who had convulsions seemed most benefited. So, in Italy, electric convulsions were tried [39] and found to work. In fact, the induction of convulsions with the electric current had distinct advantages over that with insulin or metrazol in that the stimulation could be better controlled. Also, the patients usually had amnesia for the whole performance, whereas the patients given metrazol often complained bitterly of the aura before the fit. With the accumulation of clinical experience, insulin has now been found to be of benefit in certain cases of schizophrenia, and its use is largely reserved for them. Electric shock has shown that it can usually shorten depression, especially the melancholias of the involutional period. Manic states are helped to some extent. Schizophrenia can often be improved partially and temporarily. The effect of convulsive shock therapy on the psychoneuroses is still a matter of controversy.

A great deal of good treatment is being carried out with these methods, but they still remain empiric. That many patients are helped is obvious. That the practice of psychiatry has received a great stimulus and boon is not to be questioned. But the man who uses shock therapy still does not know what goes on in the brain when he gives an electric shock. Our earnest aim in the future is to learn this.

NEUROLOGY

To tell the story of neurology by sequential exposition of different episodes, such as the polemic over the neuron theory, the search for tracts, the elucidation of the basal ganglia or the introduction of electroencephalography, would give a distorted historical impression. Innumerable investigations were going on simultaneously in this crowded century. The studies ran parallel and cross fertilized each other to a great extent. Many investigators did work in more than one field. To

37. Sakel, M.: Schizophreniebehandlung mittels Insulin-Hypoglykämie sowie hypoglykämischer Schocks, Wien. med. Wchnschr. **84**:1211, 1265, 1299, 1326, 1353, 1383 and 1401, 1934; **85**:35, 68, 94, 121, 152 and 179, 1935.

38. von Meduna, L.: Die Konvulsionstherapie der Schizophrenie, Psychiat.-neurol. Wchnschr. **37**:317, 1935.

39. Bini, L.: Experimental Researches on Epileptic Attacks Induced by Electric Current, Am. J. Psychiat. **94**:172, 1938.

bring this out, a chart has been constructed (fig. 3) showing five streams of neurologic activity, beginning about 1847 and converging to empty into the pool of knowledge we call neurology as it is in 1947. These streams have been arbitrarily chosen; but in general they show five sorts of research carried on by different groups of men, but all of them neurologists in the broad sense of the word. All were interested profoundly in the study of the nervous system.

In the center is the line of clinical neurologists.[40] The names are familiar to us all and divide themselves into three schools. The most

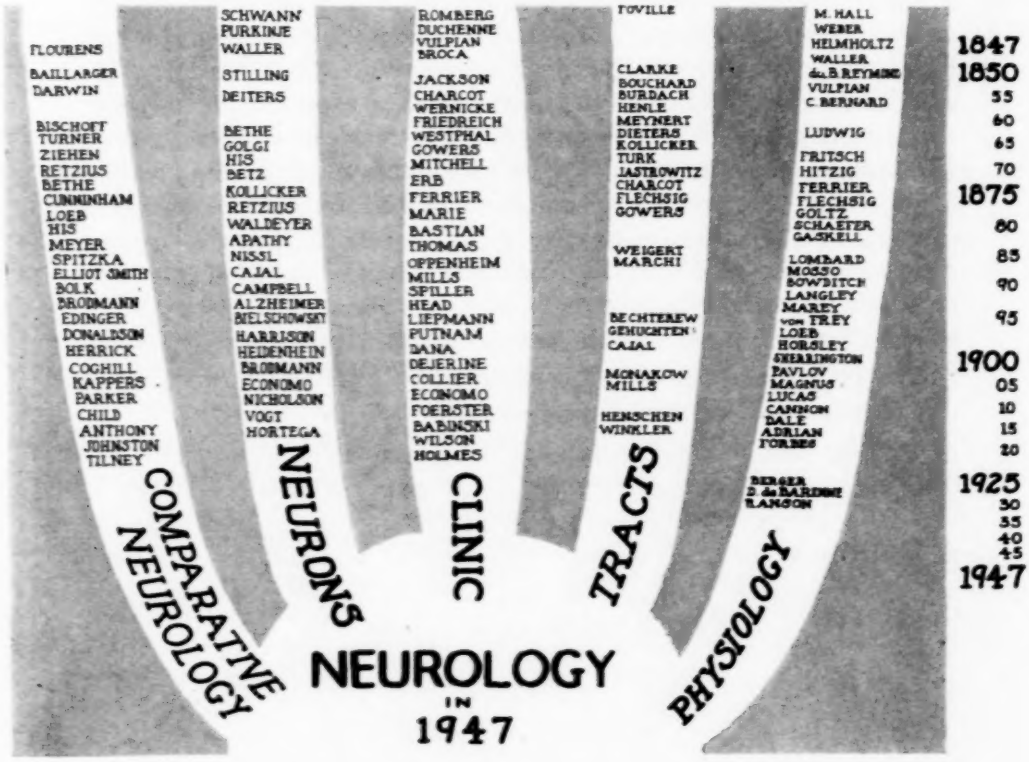

Fig. 3.—A diagram showing five streams of neurology, all flowing into a common pool, which is labeled *Neurology 1947*. The central stream lists the main clinicians, arranged in relation to the years indicated at the right. Each name appears approximately at the level of the year in which the important contribution was made. In the other streams are indicated the men who studied anatomy and physiology of the tracts, the physiology of the nervous system and, in a more general way, the anatomy and physiology of the nerve cells (neurons) and the men who made contributions in comparative neurology which were of importance to neurology.

influential was the French, from Duchenne and Charcot through Marie to such recent men as Babinski. Here, clinical observations and descrip-

40. Garrison, F. H., in Dana, C. L.: Textbook of Nervous Diseases, ed. 10, New York, William Wood & Company, 1925.

tions were emphasized and carried out with insight and assiduity. Jackson and Gowers gave the English school its phenomenal start, which has carried on to the present through a long line of able neurologists, centering mostly around the National Hospital in Queen Square. Many of them studied at Oxford under Sherrington; so the interest in physiologic problems is noticeably greater than in Paris, where the background was mostly the microtome and the microscope. In Germany the great neurologists did not have a center. They were individuals who rose to important posts in various universities. Romberg [2] can be looked on as the first neurologist in the modern sense of the word. He took the confused material of clinical neurology and organized it, describing important syndromes. His handbook in 1840-1846 made the subject a workable specialty. He was soon followed by such men as Erb, in Heidelberg; Friedreich, of Wurzburg, and Wernicke, in Breslau, each with his own clinic and special interests. After 1890 the schools began to mingle; more students from London went to Paris or Berlin and vice versa. The field of neurology became a broader discipline.

Many clinical neurologists have also been good anatomists and pathologists. Charcot, Gowers and Mills, for example, worked in the laboratory and studied the anatomy of the tracts (see *Tracts,* fig. 3). Before this, however, a group of anatomists took up the study of tracts in the cord and brain. They had been started by Bouchard's discovery of secondary degeneration in tracts (1866) and Flechsig's [41] studies of developmental myelination. A great stimulus was the introduction of new staining methods with the aniline dyes. The Weigert method for normal myelin sheaths and the Marchi method for degenerated myelin accelerated progress. In a short period of years the anatomists, from Meynert (1869) to Winkler (1918), had uncovered a great body of facts concerning the connections of the central nervous system. After 1900 the influence of the physiologists and the comparative anatomists became more and more obvious.

The study of the physiology of the nervous system goes back for centuries. As far as our epoch (1847-1947) is concerned, it can be said to take in the last of the work of Marshall Hall, who wrote about reflex action until shortly before his death, in 1857, and to start off reanimated by the great contributions of von Helmholtz and duBois-Reymond. Hall's studies were, of course, strongly influenced by the important discoveries of his predecessors Bell and Magendie. These three men started the modern concept of spinal function.[42]

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41. Flechsig, P.: Die Leitungsbahnen im Gehirn und Rückenmark des Menschen auf Grund entwickelungsgeschichtlicher Untersuchungen, Leipzig, Wilhelm Engelmann, 1876.

42. Fearing, F.: Reflex Action, Baltimore, Williams & Wilkins Company, 1930.

Emil duBois-Reymond is the greatest name in the early history of electrophysiology. In 1848 he published the first volume of his book: "Thierische Electricität"; in 1849 he introduced faradic stimulation by means of coil and break shocks. In a long life as professor in Berlin, he laid the foundations of the physiology of muscle and nerve. Simultaneously, an even greater name in science appears in the neurologic field for a short time, that of Hermann von Helmholtz, who developed the theory of the conservation of energy. This epoch-making paper was published in 1847.[3] Immediately after that he began studying the rate of conduction of the nerve impulse, and in 1850 published that remarkable contribution. These men, with others, such as Schaefer, Lombard, Bowditch, Richet and Gotch, were the forerunners of Sherrington, who between 1895 and 1935 brought the knowledge of reflex action from primitive beginnings to the status of a mature science. Through his pupils Lucas, Adrian, Forbes and many others, Sherrington was father to the newer electrophysiology of the nervous system.

Other men in the physiologic stream busied themselves with cerebral localization, after Fritsch and Hitzig had shown the way. Ferrier, Flechsig, Munk, Sherrington and others did much in these years between 1880 and 1910 to map out the cerebral cortex. Other physiologists described the function of the autonomic nervous system—Claude Bernard, Gaskell and Langley. These diverse approaches to the physiology of the nervous system brought forth facts which had a profound effect on neurology and clinical medicine.

A rather special group of investigators were those who worked on the nerve cells, rather than the tracts. In figure 3 they are indicated in the stream marked *neurons*. In contrast to the "tract" neurologists, they were workers with the high power lenses of their microscopes. The first group were those who discussed the neuron theory, a polemic that went on from Waller's time to Harrison's. The other workers with nerve cells were those who described the cells of the cerebral cortex and mapped out the areas—Betz, Nissl, Campbell, Brodmann, von Economo and Vogt. Lastly come the few who have studied the nucleus with the high power lens and special chemical methods to determine the chemical changes taking place; Heidenhain and Nicholson were pioneers in this field. With the modern technics of polarized light and the electron microscope, a new era is just beginning.

Comparative neurology, largely the work of anatomists, has been a stream of influence somewhat separate from the others, but nonetheless important. A few clinicians, like Meyer and Tilney, have been fascinated by the subject and have made contributions. But on the whole the workers have been professional biologists. From Flourens, with his primitive experiments in the first half of the nineteenth century, to

Ariëns Kappers,[43] with his beautiful and comprehensive work on comparative anatomy, published in 1920, there has been steady contribution to the study of the brains of lower animals and their relation to the brain of man. The foundation work was done by such anatomists as Ziehen, Bethe and Edinger. Elliot Smith [44] deserves special note for his contribution to the understanding of the development of speech and binocular vision. Herrick,[45] Coghill [46] and Parker [47] made the function of the central nervous system understandable by their knowledge and teaching of comparative neurology. Without the genius of these men, clinical neurology would long have stayed a static group of syndromes.

Neurology has reached the level on which it stands in 1947 by the close cooperation in the last fifty years of anatomist, physiologist and clinician. Looking ahead, one speculates that in the years soon to come chemistry will have a larger and larger share in the elucidation of the unknown.

NEURONS, TRACTS AND CORTICAL FUNCTION

In 1847 the cell theory of the anatomy of the body was not yet ten years old. New staining methods and improvements in the microscope rapidly revealed cellular relations heretofore unsuspected. Among them was the relation of the axon to the nerve cell and the dendrites. Many workers assembled these observations to make the neuron theory possible. Although it is essentially part of the general cell theory, it was slow in being accepted. In fact, a polemic of fifty years' duration went on among histologists. At first the nerve cell and the axon were thought to be separate structures. Weigert's staining methods proved the continuity of the nerve cell and the axon in 1871, and Bethe's intravital methylene blue stain demonstrated this even more clearly in 1875. It was thought by some good microscopists, however, that the axons of one nerve cell were continuous with the dendrites of the next cell, making the nervous system a continuous network, and that the neurofibrils passed from one neuron into the next. This conception was not borne out by the beautiful silver preparations of Ramon y Cajal and Bielschowsky (1903). By 1900 most anatomists had accepted the three essentials of the neuron theory: (1) that each neuron consists of a cell body together with the protoplasmic outgrowths, axons and dendrites;

43. Ariëns Kappers, C. U., and Fortuyn, A. B. D.: Vergleichende Anatomie des Nervensystems, Haarlem, Netherlands, Erven F. Bohn, 1920.

44. Smith, G. E.: Essays on the Evolution of Man, London, Oxford University Press, 1927.

45. Herrick, C. J.: Brains of Rats and Men, Chicago, University of Chicago Press, 1926.

46. Coghill, G. E.: Anatomy and the Problem of Behavior, New York, The Macmillan Company, 1929.

47. Parker, G. H.: Humoral Agents in Nervous Activity, Cambridge, Mass., Cambridge University Press, 1932.

(2) that transmission of impulses is in one direction only—dendrite to cell body to axon, and (3) that the neurons are the structural units of which the nervous system is composed and that they stimulate each other by contact at the synapse. This all seems so obvious now that one can hardly understand the long controversy. It was Harrison's definitive demonstration, in 1910, of the growth of axons out from nerve cells in culture that finally quieted all argument.

Although the basic anatomy of the nervous system was not settled, many investigators had gone ahead on the basis of Waller's degeneration experiments (1850) and Bouchard's observation (1866) that a tract cut off from its nucleus degenerates forthwith. Immediately, active study of tracts in the spinal cord and brain was taken up, both in experiments on animals and in lesions occurring in man. Names such as Meynert, Deiters and Türk are connected with many discoveries in the crowded twenty years between 1866 and 1886. In the midst of this, Flechsig brought out his ontogenetic methods and wrote his famous "Leitungsbahnen im Gehirn und Rückenmark" in 1876. The new methods of Weigert and Marchi brought fresh zest to the pursuit of tracts, and through the early years of this century the work went on with ever increasing refinement in the hands of van Gehuchten, von Monakow, Henschen, Winkler and others. More and more these investigations were made by neuropathologists rather than anatomists, some of the important men being clinical neurologists as well, such as Charcot, in Paris, Gowers, in London, and Mills, in Philadelphia. This remarkable era of discovery ended about 1900. The greater part of the complicated skein of tracts had been unraveled, described and named. The opportunity for rapid and exciting progress went to the students of the cortical architecture and to the physiologists.

In 1874 Betz had described the giant pyramidal cells of the motor area of the cerebral cortex. Campbell [48] in 1903 published his atlas of the cortex, showing that the arrangement of nerve cells differs in the various areas and that these areas have functional significance. Brodmann,[49] (1909) from Vogt's laboratory, soon produced a much more detailed study of the cellular architecture of the cortex, with a map of the cortex of man which is used to this day. Von Economo and Vogt have added to this knowledge, and the physiologists have taken over and shown the relation of histology to function. Dusser de Barenne [50] and

48. Campbell, A. W.: Histological Studies on the Localization of Cerebral Function, Cambridge, Mass., Cambridge University Press, 1905.

49. Brodmann, K.: Vergleichende Lokalisationslehre der Grossgehirnrinde in ihren Prinzipien dargestellt auf Grund des Zellenbaues, Leipzig, Johann Ambrosius Barth, 1909.

50. Dusser de Barenne, J. G., and McCulloch, W. S.: Functional Organization in Sensory Cortex of Monkey, J. Neurophysiol. **1**:69, 1938.

his students especially are to be credited with new electrical and chemical methods for the study of functional localization in the cortex.

There are, however, two other approaches to the study of cortical function—the physiologic and the clinical. Both were thoroughly explored during this century. First it is well to take up electrical stimulation of the cortex, not because it came first, but because it is closely related to the study of the cellular architecture of the cortex just discussed. Fritsch and Hitzig, in 1870, made their famous discovery of the electrical excitability of the "motor area" of the cortex in laboratory animals. Quickly work was taken up by such men as Ferrier (1872), Flechsig (1876), Munk (1877) and Horsley (1884), and with refinement of method the electrically excitable areas in many mammals were mapped out. Sherrington did much to make the work more precise and to learn about the motor cortex of monkeys and primates, even a gorilla being studied. Vogt checked his *Architektonik* areas with the electrode method in several species of monkey. Dusser de Barenne showed that the laminar, as well as the topographic, distribution was important. By destroying outer layers, he was able to stimulate the large pyramidal cells of lamina 5. New technics in surgery made possible the application of electrical stimulation to the cortex of man. Cushing by initiating and developing local anesthesia was able to expose the brain in a conscious patient. Before this, in animals, motor responses alone could be studied. Now, in man, Cushing made possible the mapping out not only of the motor cortex, but also of certain sensory areas, where stimulation caused subjective feelings reportable by the conscious patient. The knowledge of cerebral function was thus greatly enlarged, especially by the extensive studies of Foerster [51] in this field.

The older and slower method of studying cerebral localization is clinical. Gall and Spurzheim's phrenology (1819) was a rudimentary sort of localization that led the way to a scientific study of cortical function. Bouillaud (1825) and Bugh (1836) made isolated contributions, but it remained for a surgeon in Paris, Paul Broca, to describe the motor speech area and to demonstrate it in such a way that the idea of motor aphasia was accepted. He was the first to localize a cerebral abscess and to operate (1861). In 1874 Wernicke described sensory aphasia, alexia and agraphia. Jackson (1875) described focal convulsions and throughout his long career added to the knowledge of cerebral localization. Many other clinicians of the English school contributed, including Ferrier, Bramwell, Head, Holmes and Wilson. In France, the great school of Charcot had much to say about the localization of cerebral function in contributions from Pitres, Marie and Dejerine.

51. Foerster, O., and Penfield, W.: Structural Basis of Traumatic Epilepsy and Results of Radical Operation, Brain **53**:99, 1930.

It was the development of neurosurgery, however, that began the most rapid advance in knowledge of this subject. Broca has been mentioned. Horsley, Cushing and Foerster pushed the knowledge ahead rapidly. Moniz, of Lisbon, with his leukotomy operation on the frontal lobe opened a new volume to the study of the function of the frontal areas.[52] Now, with the increasing number of trained surgeons in the field, new and accurate data are being steadily accumulated. It is an active subject at the moment,[53] with history in the making.

INTEGRATION

The highest centers, which are the climax of nervous evolution, and which make up the "organ of mind" (or physical basis of consciousness) are the least organized, the most complex, and the most voluntary. So much for the positive process by which the nervous system is "put together"—evolution. Now for the negative process, the "taking to pieces"—dissolution. (J. Hughlings Jackson,[54] 1884, Croonian Lecture.)

In the multicellular animal, especially for those higher reactions which constitute behavior as a social unit in the natural economy, it is nervous reaction which *par excellence* integrates it, welds it together from its components, and constitutes it from a mere collection of organs an animal individual. (Charles S. Sherrington,[9] 1906, Silliman Lecture.)

Sherrington's work, produced between 1893 and 1938 in his laboratories at Liverpool and Oxford, is a monumental contribution to the understanding of the central nervous system. Not only are the numerous publications admirable singly, but they show a steady working toward a well thought-out goal. Most of his predecessors who had worked on reflex physiology (one might mention DuBois-Reymond, Ludwig, Lombard, Goltz and Bowditch) had made important, but more or less isolated, contributions. Goltz was the exception. Through many years (1870 to 1900) he experimented on the brain and spinal cord, removing various parts of the central nervous system in different animals. He eventually described the functions of "spinal animals" and their limitations. Also, he showed that decerebration has different effects in lower and higher animals, the loss being more profound the more highly organized the nervous system. In this laboratory Sherrington worked during his training period, returning to Cambridge to take a fellowship under Langley. Sherrington's first work on spinal reflexes and decerebrate rigidity appeared at the century's end, showing the influence of Goltz but the originality of Sherrington. After 1900 he was well

52. Freeman, W., and Watts, J. W.: Psychosurgery, Springfield, Ill., Charles C Thomas, Publisher, 1942.

53. Bucy, P. C.: Precentral Motor Cortex, Urbana, Ill., University of Illinois Press, 1944.

54. Taylor, J.; Holmes, G., and Walshe, F. M. R.: Selected Writings of John Hughlings Jackson, London, Hodder & Stoughton, Ltd., 1931.

55. Footnote deleted.

launched in a program of studying reflex action, and in 1906 he published his epoch-making work, "The Integrative Action of the Nervous System." [9]

The idea of the central nervous system as the integrator of simple reflexes into more complex patterns, the whole being more than a sum of the parts, is fundamental. Sherrington first emphasized this and gave to physiologists the concepts of integrated reflexes, inhibition, facilitation, reciprocal innervation and reenforcement. To the anatomist, he gave the concept of the brain and cord as a composite of many specialized nuclei and tracts, which can be studied separately or in groups, but function normally only as an integrated whole. His demonstration of proprioceptive sensibility and all it means for an understanding of posture and the more automatic movements made possible the elucidation of the functions of the basal ganglia, which began about 1912.

Certain ideas in the concept of the integrative action of the nervous system take one back to the teachings of Hughlings Jackson.[54] It would be interesting to know what influence he had on Sherrington. Jackson's approach was utterly different from that of Sherrington. The former was a clinician and philosopher; the latter, one who used the experimental method and avoided speculation and philosophizing about his results until he had reached a ripe old age. Jackson studied philosophy and at one time almost gave up medicine for philosophy. He took many of his ideas directly from Herbert Spencer. Nevertheless it is remarkable to note how his clinical observations and logical deductions therefrom built up an idea of the physiology of the nervous system which thirty years later was to be largely verified by Sherrington's experiments. The theory that the central nervous system is divisible into functional levels, the more complex controlling the less complex; the theory of release of lower levels by destruction of higher ones; localization; the spread of impulses—all these clinical deductions of Jackson's, brilliant at the time, and for all time a model, were later elaborated, explained and made more precise by the experiments of Sherrington.

As far as one can tell, Jackson had no direct effect on Sherrington, who never spoke of him as one of his preceptors. Nevertheless, Jackson's influence on neurologic thinking was great and by 1890 was largely accepted. It probably spread from the clinic to the laboratories of physiology. In fact, Sir David Ferrier probably was a link between the two great men; he worked with Jackson and did experiments on cerebral localization in the seventies, and Sherrington worked with Ferrier in the nineties.

Whatever the historical influences, the thoughts and observations of these two men have now joined to give to a new generation of neurologists an understanding of the nervous system that is greatly broadened.

Instead of the pedantic teacher of syndromes, or the long-memoried observer of many autopsies, the medical student is now taught by a neurologist who thinks in terms of how the central nervous system works, in terms of evolution and dissolution, of integration and disintegration.

THE BASAL GANGLIA

Thirty-five years ago practically nothing was known of the functions of the basal ganglia. The gray masses lying in the lower forebrain and upper brain stem may be broadly described to include the putamen, caudate nucleus, pallidum, thalamus, subthalamus, red nucleus, substantia nigra and nuclei in the tegmentum, and the reticular formation. To restrict the term narrowly to the ganglia of the striate body seems unphysiologic. This array of conspicuous structures had been described morphologically for over one hundred years, but in 1910 the great majority of neurologists had not the slightest idea of their function. Scattered clinicopathologic observations had been made by Landouzy (1878), Anton (1896), Brissaud (1902), Manschat (1904) and Jelgersma (1908). But these observations were not brought together, and no concept was formed. Probably, as in most similar situations in the history of science, the minds of neurologists were not prepared to see the meaning of the data available. It took the basic work of Sherrington on decerebrate rigidity and the experiments of his pupils on postural reflexes to make ready the minds of the clinicians and pathologists. Sherrington outmoded the too simple concept of an "upper motor neuron" and a "lower motor neuron" and emphasized the importance of postural reflexes in all motor phenomena.

Suddenly, from 1909 to 1913 a group of important papers appeared. Jelgersma, in 1909, and Alzheimer, in 1911, described the cerebral lesions of Huntington's chorea. Vogt wrote *"Quelques considerations generales á propos du syndrome du corps strié"* in 1911. Wilson described hepatolenticular degeneration in 1912. In the same year Lewy wrote on the pathology of paralysis agitans. Pfeiffer added to the description of Huntington's chorea in 1913. The war stopped this rapidly advancing work; but in another way the war contributed, for in 1916 an epidemic of encephalitis lethargica began in central Europe and in a few years spread over the world, gradually dying out in 1928 to 1931. Von Economo gave the best early description of the disease, and in the following years a flood of clinical and pathologic contributions proved beyond doubt that this type of encephalitis had a predilection for the basal ganglia. Many syndromes were described, and autopsy reports made it clear that the relation of these ganglia to posture, rigidity, tremor, chorea and athetosis was a most important one. In these cases of encephalitis the lesions were usually so diffuse that it was difficult to localize certain functions in any one ganglion. Some rare cases

were of use in indicating localization, but on the whole the epidemic advanced knowledge by its mass demonstration, not by its specificity in detail.

The cases that have helped in localization are the rare ones in which a focal hemorrhage or metastasis of a tumor has locally injured the nervous system. Such a case as that of a hemorrhage in one subthalamic nucleus, reported by Martin, was important in localizing hemichorea. As the data increased and the pathologic work became more exact, a workable knowledge of what the basal ganglia meant in motor function emerged.[56]

Experimental lesions made in the basal ganglia of laboratory animals aided little in the earlier years. Of course, the work of Sherrington and his school was of great importance, but in a general physiologic way. The extensive experiments of Ranson brought new physiologic concepts and helped explain clinical phenomena. He even succeeded in producing symptoms in a monkey that suggested an incomplete Parkinson syndrome by placing bilateral lesions in the hypothalamic region. This was reported in 1939.[57] Much work has been done in Fulton's laboratory at Yale in relation to cerebral lesions and motor function. All this is going on now and is too recent to be reported here. The riddle of the basal ganglia is rapidly being solved.

THE CEREBROSPINAL FLUID

Although the cerebrospinal fluid had been mentioned by such men as Galen and Vesalius, and described by Cotugno in 1764,[58] it was Magendie, in 1842, who adequately described it and brought it to the attention of members of the medical profession. Twelve years later Faive studied the circulation of the fluid, and in 1876 Key and Retzius published their researches into the physiology of the formation, circulation and absorption of the fluid. Thus, the field was prepared for the clinicians, but they were slow in taking advantage of the new knowledge. In 1885 Corning[59] did puncture the sac with a needle for the purpose of introducing cocaine. His object was to cause anesthesia and prevent masturbation! This was the first lumbar puncture. Wynter, in 1891, drained the cerebrospinal fluid in 4 cases of tuberculous meningitis.

56. Denny-Brown, D.: Diseases of the Basal Ganglia and Subthalamic Nuclei, in Christian, H. A.: Oxford System of Medicine, New York, Oxford University Press, 1945, vol. 6, chap. 11. Benda, C. E., and Cobb, S.: On the Pathogenesis of Paralysis Agitans, Medicine **21**:95, 1942.

57. Magoun, H. W.: Recent Contributions to Extrapyramidal System, Bull. Northwestern Univ. M. School **20**:180, 1946.

58. Viets, H. R.: Domenico Cotugno: His Description of Cerebrospinal Fluid, Bull. Inst. Hist. Med. **3**:701, 1935.

59. Corning, J. L.: Spinal Anesthesia and Local Medication of the Cord, New York M. J. **42**:483, 1895.

This was done with a trocar, through an incision in the skin. It remained for Quincke, in 1895, to simplify the procedure so that it became practical for diagnosis.[60] He used a plain needle and went right through the skin into the subarachnoid space. From then on the study was advanced rapidly by such men as Widal and Sicard, in France, and Plaut and Nonne, in Germany. In 1912 Mestrezat published his monograph on the chemical composition of the cerebrospinal fluid in health and in disease. His quantitative determinations of the protein, sugar and chloride contents gave definite results which allowed chemical syndromes to be described. Some of these values were characteristic of certain disease processes; so accuracy in diagnosis was advanced. Not only that, but the chemical studies suggested to Mestrezat that the fluid was not a secretion of the choroid plexus but a dialysate in equilibrium with blood plasma. This concept started a controversy which has not yet been settled.

While working together on experimental meningitis in 1918-1919, Ayer, Weed and Wegefarth conceived the idea of puncturing the cisterna magna in man. Wegefarth performed the first puncture, and his work was closely followed by Ayer, who kept on with the technic and gave the method its practical standing in diagnosis and therapy.[61] The cisternal route also made possible double punctures, with needles simultaneously recording pressures in the lumbar sac and the cisterna magna. Ayer showed that spinal block could easily be demonstrated in this way and added to the knowledge of the physiology of the subarachnoid space by experiments on the hydrodynamics of the fluid. Weed continued with studies of the source and absorption of the fluid in animals.

At about this time Dandy drained off fluid and replaced it with air, both by the lumbar route and through a trephine hole into a cerebral ventricle; then, applying roentgen rays, he made the first ventriculograms and pneumoencephalograms. This method of visualizing the shape of the brain made possible accurate localization of tumors in many cases in which clinical signs were either absent or inconclusive. Three years later Sicard and Forestier (1921) introduced a substance opaque to the roentgen rays—iodized oil U. S. P.—into the arachnoid space. This proved to be an especially useful procedure for localizing spinal lesions.

In the last twenty-five years all these methods have been refined and improved. No great changes in technic have taken place. The examination of the cerebrospinal fluid, however, and the study of the subarachnoid space remain of great importance in neurologic diagnosis.

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60. Merritt, H. H., and Fremont-Smith, F.: Cerebrospinal Fluid, Philadelphia, W. B. Saunders Company, 1937.

61. Ayer, J. B.: Puncture of the Cisterna Magna, Arch. Neurol. & Psychiat. **4**:529 (Nov.) 1920.

BRAIN WAVES

Es war dies das erste Ergebnis, das dafür sprach, dass wahrscheinlich beim Menschen ähnlich wie bei Kaninchen, Hunden and Affen sich ständige elektrische Ströme von der unversehrten Grosshirnrindenoberfläche ableiten lassen. (Berger,[62] 1929.)

It was in these words that Berger announced that he had succeeded in making a human electroencephalogram. He had worked five years on animals and patients, and he announced his discovery in a paper entitled "Ueber der Elektrenkephalogramme des Menschen." Before his death, he published eighteen more papers, which laid the foundations of present day electroencephalography. He established that the electrical beats originated in neuronal tissue and that they changed with age, with sensory stimuli and with physicochemical changes in the body. Berger is rightly considered the founder of clinical electroencephalography, and without his careful and courageous pursuit of the subject medicine would have been denied this diagnostic tool for some time longer. He was not, however, the first to record electrical fluctuations from the brain. This was done by Caton[63] sixty years ago, and his results appeared in the *British Medical Journal* in 1875. The string galvanometer greatly improved electrical recording, and Caton's work was amply confirmed. Forbes first used radio tubes to amplify the action potentials relayed to his string galvanometer. With MacPherson, he made an electroencephalogram from the cortex of the guinea pig in 1921. Neminski,[64] in 1925, even made records through the intact skull and described two sorts of waves, which are now commonly called the alpha and the beta waves.

After Berger's great work, W. G. Walter, a pupil of Adrian's, made the next important contribution. At the Maudsley Hospital, in London, he developed a technic for the localization of intracranial lesions. Bipolar electrodes were used, and the method is now the accepted one for localization. About this time Adrian contributed an electroencephalographic technic using the Matthew oscillograph. In Brussels, Bremer was carrying out experimental work on animals.

It has been impossible in this historical sketch, brief as it is, to stick to my policy of not mentioning workers now active. If I had done so, only Caton and Berger would appear. The field is so new and is expanding so rapidly that little can be said with historical perspective.

62. Berger, H.: Ueber das Elektrenkephalogramm des Menschen, Arch. f. Psychiat. **87**:527, 1929.

63. Caton, R.: Electric Currents of the Brain, Brit. M. J. **2**:278, 1875.

64. Práwdicz-Neminski, W. W.: Zur Kenntnis der elektrischen und der Innervationsvorgänge in den funktionellen Elementen und Geweben des tierischen Organismus. Das Elektrocerebrogramm der Säugetiere, Arch. f. d. ges. Physiol. **209**:362, 1925.

The first societies of electroencephalographers have just been formed, in 1946, and the first meetings have just been held. These enthusiastic men will carry on.

NEUROSURGERY

The science and art of neurological surgery demands the whole life of the surgeon; all his mental and physical energy. A teaching hospital . . . which does not provide a surgical neurological department . . . neglects a splendid opportunity and fails to provide for the relief and cure of the most dreadful diseases to which mankind is heir. (Sir Charles Ballance.[65])

Before 1900 there was little that resembles modern neurosurgery. To develop the specialty earlier would have been impossible, because the technics on which neurosurgery rests were not sufficiently developed. Antisepsis was not good enough. Asepsis had to be brought to a high level of perfection (fig. 1). Surgical anesthesia had been in use for fifty years, but it, too, had to be perfected to allow for long operations on the brain. Hemostasis had to be effective in bone and brain, where ordinary instruments were useless. Lumbar puncture was not in use until after 1895.

Besides the perfection necessary from the standpoint of surgical technic, neurology had to be developed to a point at which localization of lesions within the brain and cord was accurate. David Ferrier may be said to have brought this about. He took the lead from Fritsch and Hitzig (fig. 3) and performed a colossal amount of experimenting in the next ten years. By 1883 he was able to say that the time had come when the brain of man could be surgically approached. The understanding of the physiology of the organ had reached a point at which symptoms indicated where to operate and knowledge of localization also indicated where *not* to operate. In a general way, the main projection areas of the cortex were mapped out, and a rudimentary knowledge of the brain stem and cerebellum was available. Penfield suggests that it was probably due to Ferrier's urging that Godlee, in 1884, removed the first cerebral tumor localized scientifically. The invention of the ophthalmoscope by von Helmholtz in 1850 led to important neurologic contributions by Hughlings Jackson in 1863 and 1866. Also important for neurosurgery was the perimeter, developed by von Graefe and Foerster.

Before Horsley there was neurosurgery but there were no neurosurgeons. Ballance [66] gave a review going back to the trephine operations done by neolithic man. Hippocrates used the trephine, apparently with occasional success. In Pepys' diary, under the date of Feb. 3, 1677,

65. Ballance, C.: Dawn and Epic of Neurology and Surgery: Macewen Memorial Lecture, Glasgow, Jackson, Wylie & Co., 1930.

66. Ballance, C.: Glimpse into the History of the Surgery of the Brain: Thomas Vicary Lecture, London, The Macmillan Company, 1922.

there is a description of an operation on Prince Rupert. He was "trepanned" for what seems to have been a temporosphenoidal abscess and recovered. John Hunter (1728-1793) performed several successful "trepannations" for depressed fracture. By 1890 many surgeons were performing operations on the brain with some success. MacEwen, in England, did good work with abscesses. Keen, in Philadelphia, had been stimulated by the special hospital for nervous diseases founded during the Civil War, where he worked with Weir Mitchell. At the first meeting of the Congress of Physicians and Surgeons held in Washingon, D. C., in 1888, Ferrier and Horsley came over to discuss localization and the surgery of cerebral tumors. A symposium was held with such men as Keen, Park, Mills and Starr.

Sir Victor Horsley (1857-1916) was the first specialist in neurosurgery. He devoted his life to it and prepared himself by a long training in operations on dogs and monkeys. Much of his experimental work has been of permanent value in the field of localization and endocrine glands. His stereotactic instrument, designed with Clarke, is still in use and has added much to the knowledge of cerebral physiology. As a surgeon he was unique and courageous. Trained in the old school, his assets were great knowledge of anatomy, speed and dexterity. His introduction of bone wax and muscle stamps for hemostasis made his operations possible. According to present standards, his technic was rough and his nursing and after-care were primitive. His mortality rate would have discouraged a less ardent soul. Mixter and Sachs worked under him and brought back inspiration to America. Cushing, after his training under Halstead in slow, meticulous technic, spent two days with Horsley in July 1900, saw an operation on the gasserian ganglion done in the patient's home in less than an hour, could not stand it and left London.[67]

After studying with Kocher and Sherrington, Harvey Cushing (1869-1939) returned to Baltimore to finish his training. Here he began his epoch-making work on the pituitary body and in the surgery of the brain. By 1910 he was a master in the field and was elected professor of surgery at Harvard, where in the next twenty-two years he developed neurosurgery until it became a specialty of the first order. It is not so much that he made some advances in technic, such as the use of suction, hemostasis with silver clips and the electrocoagulator; his great contribution was the many-sided attack on tumors of the brain. He studied their clinical course, their histologic character, their embryologic origin and their effects on cerebral physiology, as well as the surgical attack. In May 1931 he removed his two-thousandth cerebral tumor, and in November 1932 he operated for the last time. He spent

67. Fulton, J. F.: Harvey Cushing, Springfield, Ill., Charles C Thomas, Publisher, 1946.

his remaining years studying and writing about his remarkable series of cases. Fulton [67] has recently published an excellent biography. It is not only a fine portrayal of a remarkable man but a source book for all interested in the history of neurosurgery.

In 1920 a society of neurosurgeons was formed and had its first meeting at the Peter Bent Brigham Hospital, in Boston. The charter members were Adson, Bagley, Cushing, Dowman, Elsberg, Frazier, Harvey, Horrax, Lewis, Mixter and Sachs. The senior men of this group, contemporaries of Cushing, who had developed important neurosurgical clinics, were Elsberg and Frazier. The others are still active or, like Sachs and Mixter, just retired from their teaching posts in 1947.

Charles Frazier (1870-1936), of Philadelphia, had a long and productive surgical career. He was appointed professor at the age of 31 and thereafter worked steadily until shortly before his death. His early contribution was the development, with Spiller, of the operation of anterolateral cordotomy. He organized and led an active neurosurgical clinic at the University Hospital. He added much to the knowledge of trigeminal neuralgia, both clinically and surgically, and pointed the way to better treatment of the atypical neuralgias.

During this period Charles Elsberg (1871-) was the leading neurosurgeon in New York. Like the others, he did pioneer work. In the surgery of the spinal cord he had a particular interest. In 1925 he published a monograph on the tumors of the cord, giving many points of diagnostic importance and improving the surgical approach to these problems.

In Europe neurosurgery was progressing more slowly. Fedor Krause wrote a textbook on the subject (1910) and introduced ganglionectomy to replace peripheral section of the fifth nerve. DeMartel was the brain surgeon in Paris, but never wholeheartedly went into the specialty. He devised some useful instruments, such as the motor-driven burr, a motor bone cutter and a chair for operations in the erect posture. Sargent and Armour carried on the Horsley tradition at Queen Square.

Otfrid Foerster [68] (1873-1941), of Breslau, was the most scholarly and productive of the European group. He had no problem in making up his mind to specialize exclusively in the field because he began as a neurologist and was distinguished in that discipline before he took up surgery. This he did from necessity; he said he could find no surgeon to operate in the way he considered correct. He was a careful observer, with insatiable curiosity and inexhaustible energy. In the operating room he had developed a painstaking technic and became a successful surgeon. Of his many contributions, one might choose

68. de Gutiérrez-Mahoney, C. G.: Otfrid Foerster, Arch. Neurol. & Psychiat. **46**:913 (Nov.) 1941.

for mention his work on pain, sensory pathways and dermatomes. His mapping out of the sensory areas in the cortex on patients who were conscious during operation was important. He had a great clinical experience in treating epilepsy and advanced the surgical treatment. On these patients he studied the electrically excitable areas of the cortex and the significance of epileptic auras.

In America the younger group were coming up. Ernest Sachs and Walter Dandy had been residents under Cushing in Baltimore. Sachs worked with Horsley on the thalamus and then returned to St. Louis to found and direct a large neurosurgical clinic for many years. He devised the procedure of subpial gyrectomy. Dandy stayed at Johns Hopkins and became a remarkably dextrous neurosurgeon, combining speed with accuracy. The contribution for which he will longest be known is the introduction of air into the ventricles and the subarachnoid spaces of the brain for the purpose of making roentgenologic visualizations. Ventriculography and pneumoencephalography have become standard procedures in all neurosurgical clinics.

William Jason Mixter, in Boston, had worked with Horsley and had taken up neurologic surgery before Cushing was called to Harvard. Mixter will be remembered for his beautiful laminectomies and his sound surgical judgment. In 1932 he clarified the subject of the ruptured intervertebral disk. For some years surgeons had been removing tumors of this sort from the spinal canal, calling them "enchondromas" and considering them a form of neoplasm. A few cases had been related to trauma. Mixter and his orthopedic colleague, Barr,[69] carefully studied traumatic cases; they operated and removed several cartilaginous tumors. These they recognized as normal, not neoplastic, tissue. Then, in a long series of cases, they described the clinical syndrome associated with a ruptured and protruding disk and demonstrated the relation of this syndrome to the old disease called "sciatica."

Neurologic surgery has expanded greatly since the time of these pioneers. Many other brilliant men, scarcely younger than those named here, could be mentioned. But they are still active and cannot be discussed here. Indeed, the contributions by the men now active are no less important than those of the old guard. The technics and varied disciplines required are many and difficult. That so many young men will undergo the long and rigorous training is remarkable. At the 1939 meeting of the Harvey Cushing Society there were 57 members present. There are now 231 specialists in this branch in the United States who have passed the board examinations. These are highly trained men, who must know neurology, surgery and the physiology of the nervous system. Their productivity at the present

69. Mixter, W. J., and Barr, J. S.: Protrusion of Lower Lumbar Intervertebral Disks, New England J. Med. **223**:523, 1940.

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The first societies of electroencephalographers have just been formed, in 1946, and the first meetings have just been held. These enthusiastic men will carry on.

NEUROSURGERY

The science and art of neurological surgery demands the whole life of the surgeon; all his mental and physical energy. A teaching hospital . . . which does not provide a surgical neurological department . . . neglects a splendid opportunity and fails to provide for the relief and cure of the most dreadful diseases to which mankind is heir. (Sir Charles Ballance.[65])

Before 1900 there was little that resembles modern neurosurgery. To develop the specialty earlier would have been impossible, because the technics on which neurosurgery rests were not sufficiently developed. Antisepsis was not good enough. Asepsis had to be brought to a high level of perfection (fig. 1). Surgical anesthesia had been in use for fifty years, but it, too, had to be perfected to allow for long operations on the brain. Hemostasis had to be effective in bone and brain, where ordinary instruments were useless. Lumbar puncture was not in use until after 1895.

Besides the perfection necessary from the standpoint of surgical technic, neurology had to be developed to a point at which localization of lesions within the brain and cord was accurate. David Ferrier may be said to have brought this about. He took the lead from Fritsch and Hitzig (fig. 3) and performed a colossal amount of experimenting in the next ten years. By 1883 he was able to say that the time had come when the brain of man could be surgically approached. The understanding of the physiology of the organ had reached a point at which symptoms indicated where to operate and knowledge of localization also indicated where *not* to operate. In a general way, the main projection areas of the cortex were mapped out, and a rudimentary knowledge of the brain stem and cerebellum was available. Penfield suggests that it was probably due to Ferrier's urging that Godlee, in 1884, removed the first cerebral tumor localized scientifically. The invention of the ophthalmoscope by von Helmholtz in 1850 led to important neurologic contributions by Hughlings Jackson in 1863 and 1866. Also important for neurosurgery was the perimeter, developed by von Graefe and Foerster.

Before Horsley there was neurosurgery but there were no neurosurgeons. Ballance [66] gave a review going back to the trephine operations done by neolithic man. Hippocrates used the trephine, apparently with occasional success. In Pepys' diary, under the date of Feb. 3, 1677,

65. Ballance, C.: Dawn and Epic of Neurology and Surgery: Macewen Memorial Lecture, Glasgow, Jackson, Wylie & Co., 1930.

66. Ballance, C.: Glimpse into the History of the Surgery of the Brain: Thomas Vicary Lecture, London, The Macmillan Company, 1922.

Case Reports

CEREBRAL INVOLVEMENT BY OSTEOGENIC SARCOMA ASSOCIATED WITH PAGET'S DISEASE OF THE SKULL

LOUIS O. J. MANGANIELLO, M.D.*

D. L. REIMANN, M.D.

AND

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there is a description of an operation on Prince Rupert. He was "trepanned" for what seems to have been a temporosphenoidal abscess and recovered. John Hunter (1728-1793) performed several successful "trepannations" for depressed fracture. By 1890 many surgeons were performing operations on the brain with some success. MacEwen, in England, did good work with abscesses. Keen, in Philadelphia, had been stimulated by the special hospital for nervous diseases founded during the Civil War, where he worked with Weir Mitchell. At the first meeting of the Congress of Physicians and Surgeons held in Washingon, D. C., in 1888, Ferrier and Horsley came over to discuss localization and the surgery of cerebral tumors. A symposium was held with such men as Keen, Park, Mills and Starr.

Sir Victor Horsley (1857-1916) was the first specialist in neurosurgery. He devoted his life to it and prepared himself by a long training in operations on dogs and monkeys. Much of his experimental work has been of permanent value in the field of localization and endocrine glands. His stereotactic instrument, designed with Clarke, is still in use and has added much to the knowledge of cerebral physiology. As a surgeon he was unique and courageous. Trained in the old school, his assets were great knowledge of anatomy, speed and dexterity. His introduction of bone wax and muscle stamps for hemostasis made his operations possible. According to present standards, his technic was rough and his nursing and after-care were primitive. His mortality rate would have discouraged a less ardent soul. Mixter and Sachs worked under him and brought back inspiration to America. Cushing, after his training under Halstead in slow, meticulous technic, spent two days with Horsley in July 1900, saw an operation on the gasserian ganglion done in the patient's home in less than an hour, could not stand it and left London.[67]

After studying with Kocher and Sherrington, Harvey Cushing (1869-1939) returned to Baltimore to finish his training. Here he began his epoch-making work on the pituitary body and in the surgery of the brain. By 1910 he was a master in the field and was elected professor of surgery at Harvard, where in the next twenty-two years he developed neurosurgery until it became a specialty of the first order. It is not so much that he made some advances in technic, such as the use of suction, hemostasis with silver clips and the electrocoagulator; his great contribution was the many-sided attack on tumors of the brain. He studied their clinical course, their histologic character, their embryologic origin and their effects on cerebral physiology, as well as the surgical attack. In May 1931 he removed his two-thousandth cerebral tumor, and in November 1932 he operated for the last time. He spent

67. Fulton, J. F.: Harvey Cushing, Springfield, Ill., Charles C Thomas, Publisher, 1946.

his remaining years studying and writing about his remarkable series of cases. Fulton [67] has recently published an excellent biography. It is not only a fine portrayal of a remarkable man but a source book for all interested in the history of neurosurgery.

In 1920 a society of neurosurgeons was formed and had its first meeting at the Peter Bent Brigham Hospital, in Boston. The charter members were Adson, Bagley, Cushing, Dowman, Elsberg, Frazier, Harvey, Horrax, Lewis, Mixter and Sachs. The senior men of this group, contemporaries of Cushing, who had developed important neurosurgical clinics, were Elsberg and Frazier. The others are still active or, like Sachs and Mixter, just retired from their teaching posts in 1947.

Charles Frazier (1870-1936), of Philadelphia, had a long and productive surgical career. He was appointed professor at the age of 31 and thereafter worked steadily until shortly before his death. His early contribution was the development, with Spiller, of the operation of anterolateral cordotomy. He organized and led an active neurosurgical clinic at the University Hospital. He added much to the knowledge of trigeminal neuralgia, both clinically and surgically, and pointed the way to better treatment of the atypical neuralgias.

During this period Charles Elsberg (1871-) was the leading neurosurgeon in New York. Like the others, he did pioneer work. In the surgery of the spinal cord he had a particular interest. In 1925 he published a monograph on the tumors of the cord, giving many points of diagnostic importance and improving the surgical approach to these problems.

In Europe neurosurgery was progressing more slowly. Fedor Krause wrote a textbook on the subject (1910) and introduced ganglionectomy to replace peripheral section of the fifth nerve. DeMartel was the brain surgeon in Paris, but never wholeheartedly went into the specialty. He devised some useful instruments, such as the motor-driven burr, a motor bone cutter and a chair for operations in the erect posture. Sargent and Armour carried on the Horsley tradition at Queen Square.

Otfrid Foerster [68] (1873-1941), of Breslau, was the most scholarly and productive of the European group. He had no problem in making up his mind to specialize exclusively in the field because he began as a neurologist and was distinguished in that discipline before he took up surgery. This he did from necessity; he said he could find no surgeon to operate in the way he considered correct. He was a careful observer, with insatiable curiosity and inexhaustible energy. In the operating room he had developed a painstaking technic and became a successful surgeon. Of his many contributions, one might choose

68. de Gutiérrez-Mahoney, C. G.: Otfrid Foerster, Arch. Neurol. & Psychiat. **46**:913 (Nov.) 1941.

for mention his work on pain, sensory pathways and dermatomes. His mapping out of the sensory areas in the cortex on patients who were conscious during operation was important. He had a great clinical experience in treating epilepsy and advanced the surgical treatment. On these patients he studied the electrically excitable areas of the cortex and the significance of epileptic auras.

In America the younger group were coming up. Ernest Sachs and Walter Dandy had been residents under Cushing in Baltimore. Sachs worked with Horsley on the thalamus and then returned to St. Louis to found and direct a large neurosurgical clinic for many years. He devised the procedure of subpial gyrectomy. Dandy stayed at Johns Hopkins and became a remarkably dextrous neurosurgeon, combining speed with accuracy. The contribution for which he will longest be known is the introduction of air into the ventricles and the subarachnoid spaces of the brain for the purpose of making roentgenologic visualizations. Ventriculography and pneumoencephalography have become standard procedures in all neurosurgical clinics.

William Jason Mixter, in Boston, had worked with Horsley and had taken up neurologic surgery before Cushing was called to Harvard. Mixter will be remembered for his beautiful laminectomies and his sound surgical judgment. In 1932 he clarified the subject of the ruptured intervertebral disk. For some years surgeons had been removing tumors of this sort from the spinal canal, calling them "enchondromas" and considering them a form of neoplasm. A few cases had been related to trauma. Mixter and his orthopedic colleague, Barr,[69] carefully studied traumatic cases; they operated and removed several cartilaginous tumors. These they recognized as normal, not neoplastic, tissue. Then, in a long series of cases, they described the clinical syndrome associated with a ruptured and protruding disk and demonstrated the relation of this syndrome to the old disease called "sciatica."

Neurologic surgery has expanded greatly since the time of these pioneers. Many other brilliant men, scarcely younger than those named here, could be mentioned. But they are still active and cannot be discussed here. Indeed, the contributions by the men now active are no less important than those of the old guard. The technics and varied disciplines required are many and difficult. That so many young men will undergo the long and rigorous training is remarkable. At the 1939 meeting of the Harvey Cushing Society there were 57 members present. There are now 231 specialists in this branch in the United States who have passed the board examinations. These are highly trained men, who must know neurology, surgery and the physiology of the nervous system. Their productivity at the present

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One hundred years from now, when some neurologist of the twenty-first century gives this historical review for the bicentennary of the American Medical Association, he will tell of many advances with the new technics of physics and chemistry. Words we are just learning to use will be commonplace, and new terms and concepts that we could not understand will be used. Our present theories will seem primitive. Nevertheless, the golden years of anatomy in the late nineteenth century will not be forgotten. The resurgence of neurophysiology in the beginning of the twentieth century will remain a great epoch. The development of neurosurgery will stand as an example of hard-earned medical progress by brilliant and courageous men. And, unless we pay more heed to social psychology and to the facts that psychiatry is gleaning from the study of interpersonal relations, there will be no meeting of the American Medical Association in 2047!

Massachusetts General Hospital.

Case Reports

CEREBRAL INVOLVEMENT BY OSTEOGENIC SARCOMA ASSOCIATED WITH PAGET'S DISEASE OF THE SKULL

LOUIS O. J. MANGANIELLO, M.D.*

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JOHN A. WAGNER, M.D.
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THE OCCURRENCE of Paget's disease (osteitis deformans) and osteogenic sarcoma is occasionally reported. Involvement of the skull by osteogenic sarcoma, with subsequent cerebral extension, has received little mention in the literature, only 2 cases having been reported. Wolfe and Black [1] reported a case with subdural extension and without cerebral involvement. Kirschbaum [2] presented the first known case of osteogenic sarcoma (fibrosarcoma) complicating Paget's disease associated with cerebral extension. The case to be reported here is probably the third of its type and perhaps the first to represent an osteolytic form of osteogenic sarcoma.

REPORT OF CASE

Clinical History.—K. P., a white woman aged 68, a widow, was first admitted to the University Hospital on Feb. 15, 1942, with a cyst on the left side of her forehead, which had begun to bleed after an attempted local excision by her family physician on Dec. 7, 1941. A microscopic section of the excised mass, made at the time of the original removal, was reported as showing a very cellular growth, with many mitotic figures and pronounced irregularity in the size and shape of the cells. Many giant cells were present. After the attempted removal of the original mass, the wound would bleed whenever it was dressed. The growth also increased in size.

The history revealed that ten years before she had been studied at another hospital, where a diagnosis of Paget's disease was made. In 1932 she began to have weakness in the lower extremities, which caused her to walk with great difficulty. These symptoms became progressively worse, so that since 1937 she had spent most of the time in bed. In 1941, while attempting to walk, she fractured the left femur. The rest of her past history was noncontributory. The

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From the Department of Pathology, University of Maryland School of Medicine.

1. Wolfe, A. M., and Black, W. C.: Rocky Mountain M. J. **37**:586-587 (Aug.) 1940.

2. Kirschbaum, J. D.: Fibrosarcoma of the Skull in Paget's Disease, Arch. Path. **36**:74-79 (July) 1943.

family history revealed that her father died of carcinoma of the rectum and her mother of carcinoma of the breast.

There was a large, fungating, sessile growth on the left side of her forehead. Both frontal bosses were enlarged. The rest of the examination revealed an essentially normal condition. The hemoglobin concentration was 32 per cent (Sahli). A roentgenogram of the skull revealed thickening and increase in the density of the bone, with the cranial vault presenting a peculiar, serrated appearance, interpreted as typical of Paget's disease. An area of refraction, about 4 cm. in its greatest diameter, was observed in the left frontal bone.

Biopsy of the tumor in the left frontal bone on February 25 was reported to show a very vascular, cellular growth, composed of closely packed, irregularly grouped, misshapen, fibroblastic-like cells, which were roughly oval. Intermingled with these were numerous multinucleated, polyhedral cells, which resembled osteoclasts. Cellular structures were irregular in size and shape and showed many mitotic figures. Vascularity was pronounced. Hemorrhage had occurred into the tumor. The neoplasm was interpreted as a rapidly growing osteolytic tumor. The diagnosis was osteogenic sarcoma.

The patient then received a total of 22,250 milligram hours of radium therapy, over a period of ten days. With supportive treatment she improved sufficiently to be discharged on May 2.

On July 21 she had a generalized convulsion. Her family now noted that the right thigh was crooked. The same day she was admitted to the hospital for the second time. She then seemed to be in great pain. The right thigh was angulated 45 degrees at its midportion, so that the right foot crossed the left ankle. The head was extremely large, with prominent frontal and temporal bosses. A dressing over the left frontal region covered a fungating, bleeding mass, 6 cm. in its greatest diameter. There was no nuchal rigidity. The lungs were clear, but there were a few fine rales at both bases. The heart was observed to be slightly enlarged on percussion, and the sounds were clear and regular. An aortic systolic murmur, transmitted up the right side of the neck, was noted. The abdomen was distended with gas. The liver was palpable just below the costal margin. The kidneys and spleen were not palpable. The neurologic status was normal except for hypoactive tendon reflexes and a suggestive Babinski reflex bilaterally.

Roentgenologic examination of the right femur revealed much irregularity and thinning of the cortex, with distortion of the medullary canal and diffuse decalcification of the entire bone. A transverse fracture was seen in the middle third of the femur. The two fragments were alined, but the distal fragment was displaced one-fourth the diameter of the bone medially with a 5 per cent lateral angulation. The urine was normal except for a specific gravity of 1.008. Buck's skin traction was applied, and the patient's condition improved slowly with conservative and supportive therapy until August 16, when right hemiplegia suddenly developed. From this date, she passed from a fairly alert state to a sluggish, listless, comatose condition. Death occurred on September 2, after prolonged hyperpyrexia.

Autopsy (three hours after death).—The body was 172 cm. in length and presented the habitus of Paget's disease. There were distinct enlargement of the calvaria, lumbar kyphosis and thickening of the iliac bones. The symphysis pubis was unduly prominent. A fungating mass, 6 cm. in its greatest diameter, was observed in the left frontal region. It was firm, but not bony, and showed on

section an extremely vascular, malignant neoplasm, identical in structure with the biopsy specimen taken on February 25. The skin adjacent to the tumor appeared normal, with a clean, rolled-in edge. There were no conspicuous deformities of the appendages except that incident to the fracture of the middle third of the right femur. There was considerable swelling of the bone at this point.

No abnormality of the abdominal organs in situ was noted. The right lung weighed 450 Gm.; the left lung, 400 Gm. Both showed several calcified nodules, surrounded by hyperemic areas measuring about 3 cm. in diameter. On the surface of the middle lobe of the right lung there was a raised nodule, which measured 2.5 cm. in diameter. When opened, this contained brownish fluid. In the lower lobe of the left lung there was a similar mass, measuring 1.25 cm. in diameter. Microscopic examination of the lung tissue revealed alternate atelectatic and emphysematous areas, and in selected foci the alveoli were filled with an exudate consisting chiefly of polymorphonuclear leukocytes. A well defined tumor,

Fig. 1.—Microscopic section taken from the skull showing typical Paget's disease (osteitis deformans).

bounded by compressed lung tissue, was seen. This mass was composed of irregularly distributed, lanceolate, filiform and irregularly shaped cells. Few mitotic figures were seen. Throughout the nodule there were trabeculae of bone, showing varying degrees of calcification.

The heart weighed 350 Gm. and showed moderate hypertrophy. The coronary vessels were tortuous and sclerotic. The aortic valve contained atherosclerotic plaques, and the mitral valve showed a minor degree of sclerosis. The liver weighed 1,100 Gm. Its cut surface appeared slightly sclerotic and exhibited widespread yellow spots, but no gross evidence of tumor growth. Microscopic sections revealed accumulation of lymphocytes within and about the portal triads with moderate engorgement of the sinusoids in the areas of the central veins, associated with pericentral degeneration of the hepatic cells. The kidneys weighed 150 Gm. each and were normal on gross inspection. On microscopic examination the glomeruli exhibited increased cellularity. Some had a few remaining tufts, show-

ing varied degrees of scarring, and others showed complete replacement with fibrous tissue. There was tubular cloudy swelling. Many middle-sized arteries showed splitting and reduplication of the internal elastic lamellae. There was an area of anemic infarction with typical coagulation necrosis and lymphocytic infiltration. The spleen weighed 200 Gm. Its upper pole contained an anemic infarct, which on microscopic examination presented coagulation necrosis with fragmentation of the splenic corpuscles and scattered lymphocytes. The pancreas was normal. In the duodenum, about 4 cm. from the pylorus on the posterior surface, there was an area of hyperemia, 0.5 cm. in size, with a necrotic center, involving only the mucosa. The uterus was small and fibrotic. Both ovaries were small

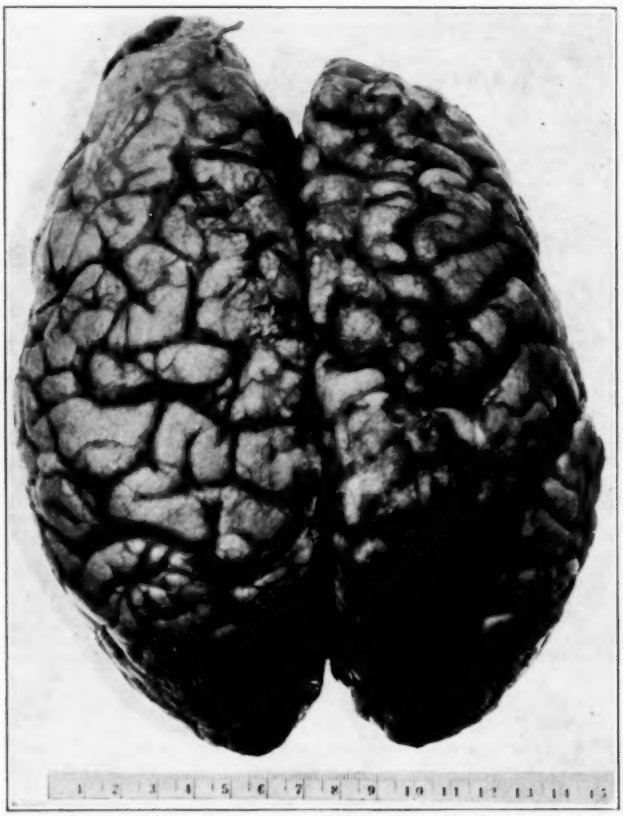

Fig. 2.—View of the cerebral hemispheres, showing a large tumor in the left frontal pole and atrophy of the convolutions of the right cerebral hemisphere.

and senile. From the cervical canal hung a red, smooth, pedunculated polyp. When the cervix was opened several smaller polypi were observed within the endocervical canal. An incision was made in the middle portion of the right femur, where a recent fracture was observed. A tumor extended 2.5 cm. on either side of this fracture and had replaced or eroded most of the cortex. Microscopic examination of selected sections from the skull and femur revealed that the cortical and trabecular bone appeared thickened and poorly calcified. The medulla was fatty and was encroached on by similar, irregularly streaked bone. Conspicuous laminations of calcareous deposits coursed irregularly in divergent and colliding

routes, forming a mosaic design (fig. 1). The sites of the tumor both in the femur and in the left frontal bone were infiltrated with neoplastic tissue, which had destroyed a large part of the normal structure. The neoplasm was not circumscribed and extended haphazardly into the medullary cavity. Filiform cells of the adult fibrocytic type comprised its stroma. Irregular, dark-staining, cuboidal and lanceolate cells with scattered polymorphonuclear giant cells made up the remainder of the tumor. Spicules of bone were distributed through the mass.

The calvaria measured 1 cm. at its thinnest portion and 2.25 cm. at its thickest part. The skull was softer than normal, but there was widening of the inner and outer tables of the diploe, with almost complete obliteration of the cancellous portion. The mass in the left frontal bone had eroded through the inner table and had involved the dura mater and the cerebral cortex. In addition to this original growth, there were several similar extradural bony growths. Gross exami-

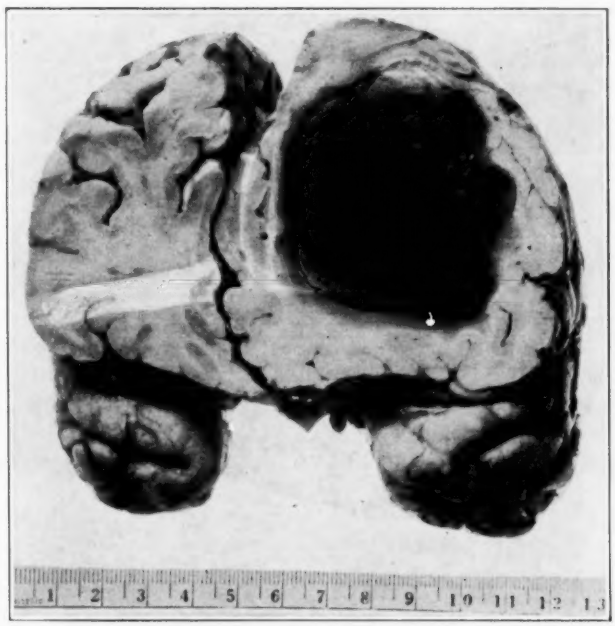

Fig. 3.—Coronal section through the tip of the frontal lobes, showing the caudal extension of the tumor in the left cerebral hemisphere.

nation of the dura over the left frontal lobe disclosed an extradural growth of yellowish tumor tissue, 1 cm. in diameter, which did not invade the subdural space. Microscopic examination revealed that the dura was thickened and showed increased fibrosis and extensive hyaline change. In places fresh hemorrhage had occurred. Some fibroblastic activity was seen, but this was minimal. A large accumulation of amorphous hyaline material was noted in the subdural space. A small deposit of tumor tissue was seen here. The dural vessels showed fibrosis and hyaline change and were occluded in places.

The cerebral hemispheres were asymmetric, the left being larger than the right (fig. 2). The convolutions on the left side were swollen and flattened, with obliteration of the sulci. When the brain was viewed from the base, moderate sclerosis of the basilar vessels was noted.

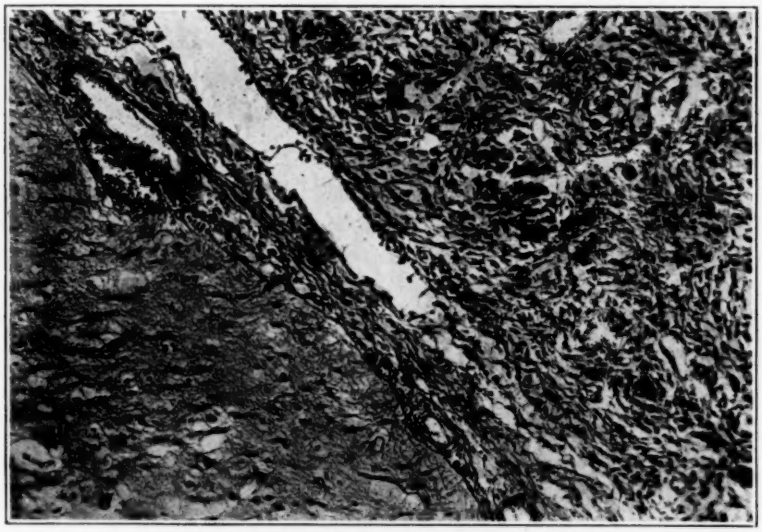

Fig. 4.—Microscopic section of the brain, showing complete filling of the subarachnoid space with tumor cells, and adjacent cortex.

Fig. 5.—Microscopic section through the left frontal lobe, showing the cortex (upper portion of the photograph) and the invading tumor (lower portion).

The tumor was observed to occupy the entire left frontal lobe, extending into the centrum ovale of the left parietal lobe just caudal to the level of the optic chiasm (fig. 3). The left frontal lobe was displaced to the right across the midline, with concomitant dilatation and distortion of both lateral ventricles to the right. Massive hemorrhage and cystic degeneration were present in the tumor. In its widest extent it occupied an area 4 by 5 cm. One of the cysts had ruptured into the subarachnoid space, with resulting subarachnoid hemorrhage. Histologically, the tumor was similar to that in the left frontal bone. In places it was well contained by the pia mater; in other areas it had invaded the subarachnoid space (fig. 4). The portions of the cortex surrounding the growth showed destruction, due to presence of the tumor and of hemorrhage (fig. 5). In places there was evidence of early infarction, numerous macrophages being present. Neuroglial reaction was moderate. Silver-impregnated sections showed an enormous increase in astrocytes in the areas surrounding the tumor.

In the basal ganglia, claustrum and insula on the left side there was much softening. The right frontal and parietal lobes presented a moderate degree of cortical atrophy (fig. 2). Microscopic sections revealed edema and congestion of the meninges. The underlying neuron cells were decreased in layers cortical II to V. Degeneration was uniform, but not particularly prominent, the changes being mainly limited to tinctorial variations. There was no evidence of tumor growth.

The pons, cerebellum and medulla were essentially normal except for degeneration of the ganglion cells in both inferior olivary nuclei.

Diagnosis.—The diagnosis was Paget's disease (osteitis deformans); osteogenic sarcoma (osteolytic type), involving the right femur, the skull and dura on the left side and the left frontal pole, with hemorrhage into, and necrosis of, the tumor and with metastases to both lungs; mild atrophy of the frontal lobes due to roentgen irradiation; pathologic fracture of the middle third of the right femur; cerebral edema of the left frontal lobe; mild internal hydrocephalus; organizing hematoma of the left frontal pole; mild diffuse subarachnoid hemorrhage; infarction of the spleen and the right kidney; polypi of the cervix; duodenal ulcer; evidence of increased intracranial tension, and lobular pneumonia.

COMMENT

Paget's disease itself is not considered neoplastic; nevertheless, its exact nature is not known. Clinically, there is an increase in the plasma phosphatase, such as is also found in cases of osteitis fibrosa. Absence of hyperparathyroidism and hyperplasia of the parathyroid glands, with a normal calcium and phosphorus content of the blood, serves to differentiate the two conditions. It is generally agreed that Paget's disease may be a metabolic disorder or, more remotely, a low grade irritative process, probably with a toxic basis.

Geschickter and Copeland [3] stated that osteogenic sarcoma occurs in from 5 to 7 per cent of the cases of Paget's disease. Conversely, the National Registry of Bone Sarcoma showed that 5 per cent of all osteogenic sarcomas arise in association with Paget's disease. These sarcomatous growths usually occur in the long bones, but may arise anywhere. They may be multiple and, as Kolodny [4] has shown, are not

3. Geschickter, C. F., and Copeland, M.: Tumors of Bone, ed. 2, New York, American Journal of Cancer, 1936, p. 288.

4. Kolodny, A.: Bone Sarcoma, Chicago, Surgical Publishing Company, 1927, p. 21.

necessarily metastatic. This observation has led some investigators to designate Paget's disease with osteogenic sarcoma as a clinical entity, but to date no clinical evidence has been offered to support such a premise. Osteogenic sarcoma in young persons is not often associated with Paget's disease, but Kolodny [4] stated that in persons over 50 years of age the presence of osteogenic sarcoma is presumptive evidence of concurrent Paget's disease.

Any of the sarcomatous bone tumors may be associated with Paget's disease. The usual form is periosteal, but chondral, osteolytic and osteoblastic forms are also seen. A few cases of unusual types of osteogenic sarcoma have been reported. Curphey [5] reported the occurrence of multiple syphilitic pagetoid lesions in which an osteogenic sarcoma subsequently developed. Metastases occurred to the dura. Jewell and Lofstrom [6] reported a case of osteogenic sarcoma associated with fragilitas ossium. (Wolfe and Black [1] and Kirschbaum [2] also reported cases.)

The case reported here may be considered unique because of its type and the location of metastases. In spite of the large invasive growth within the brain, the patient showed relatively few neurologic signs until her second admission, following the convulsive episode. After this episode, she was relatively free of neurologic symptoms until she became hemiplegic, three weeks later. Death occurred two weeks after onset of the hemiplegia. From the observations at autopsy, it can be assumed that the presence of the tumor gave rise to the convulsive episode, but that her sudden acute hemiplegia was due to the massive hemorrhage into the tumor and surrounding brain.

The mild atrophy of the right frontal and parietal lobes in this case was probably produced by the effects of radiation. This change is similar to those reported by Dyke and Davidoff,[7] who listed degenerative changes in the glia and blood vessels with secondary neuronal changes.

SUMMARY

A case of cerebral sarcoma associated with Paget's disease (osteitis deformans) and osteogenic sarcoma is presented and discussed.

This case represents the first instance of an osteolytic type of osteogenic sarcoma of the skull associated with Paget's disease with intracerebral extension.

Cerebral changes, probably the result of radium therapy, were noted in this case.

Dr. Grant E. Ward permitted the report of the clinical features presented in this case.

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5. Curphey, R. J.: Urol. & Cutan. Rev. **45**:438-443 (July) 1941.

6. Jewell, F. C., and Lofstrom, J. E.: Radiology **34**:741-743 (June) 1940.

7. Dyke, C. C., and Davidoff, L. M.: Roentgen Treatment of Disease of the Nervous System, Philadelphia, Lea & Febiger, 1942.

PHENOMENON OF CUTANEOUS SENSORY EXTINCTION

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NEW YORK

TOO INFREQUENTLY are neurologic examinations conducted with the consideration of the sensory system of the body as a total functioning, integrated unit. Examination of the motor system usually includes observations on the strength and status of muscle groups, the gait and the associated movements of the head, trunk and arms. In the sensory examination, however, this integrated function is more difficult to study. Ordinarily, the relation of one sensory area to another is not tested. Sensory perception of pinprick on the right side is noted to be normal; the left side is next tested, and it, too, shows no defect. The conclusion is too easily drawn that "pain perception is normal." The purpose of this paper is to report a disturbance of sensation which can be detected only when the sensory nervous system is regarded as a functioning unit.

Perceptual disturbances have always been extremely difficult to explain on a purely physiologic basis. The better known pathways from the surface of the body to the cortex of the brain are insufficient of themselves to account for phenomena like extinction. In some cases with a cortical lesion it has been found that sensations on one side of the body, though normally perceived with single stimuli, become extinguished when similar or mixed stimuli are applied on the opposite side. Bender, in recent articles,[1] drew attention to Heyman's law and advanced the theory that the stronger and the weaker stimuli compete and the resultant effect is retention of one percept and extinction of the other. An interesting corollary of this theory is that a lesion of one portion of the sensory cortex may result in a disturbance in function not only of the ipsilateral, but also of the contralateral, cortex. Thus, in cases of cortical lesions of one side of the brain relative disturbances will be found in perception of sensation on the other side of the brain.

Cortical lesions of the parietal lobe produce a selective disruption of the discriminative and integrative function underlying perception.[2]

From the Departments of Psychiatry and Neurology of the New York University College of Medicine, and the Psychiatric Division of Bellevue Hospital.

1. (*a*) Bender, M. B.: Extinction and Precipitation of Cutaneous Sensations, Arch. Neurol. & Psychiat. **54**:1-9 (July) 1945. (*b*) Bender, M. B., and Teuber, H. L.: Phenomena of Fluctuation, Extinction and Completion in Visual Perception, ibid. **55**:627-658 (June) 1946.

2. Fulton, J. F.: Physiology of the Nervous System, ed. 2, New York, Oxford University Press, 1940, p. 349.

Laboratory studies in recent years have revealed that inhibition of one functional region of the brain by another can be produced by means of stimulation methods.[3] In this paper we shall describe a case of cutaneous sensory extinction following an extensive unilateral ablation of the parietal and adjacent cortical areas.

MATERIAL AND METHOD

The subject of this study, a man aged 57, had had partial excision of a glioblastoma multiforme in the right temporoparietofrontal region. In addition to physical, neurologic and laboratory studies, psychometric tests were performed to determine the degree of intellectual impairment present. Special tests were made to demonstrate: (*a*) extinction phenomena in perception; (*b*) changes in sensory adaptation time, and (*c*) variations in other functions of the parietal lobe, such as graphesthesia, barognosis, stereognosis, point localization, perception of type and direction of lines, two point discrimination and texture discrimination. The results of these tests form the subject of this paper.

Extinction phenomena were demonstrated by testing according to the following plan: (1) tests of sensory perception of each side separately, with application of a single stimulus; (2) tests of perception with two similar stimuli applied simultaneously to one side; (3) tests of perception with two similar stimuli applied simultaneously to corresponding areas on the two sides of the body; (4) tests of perception with mixed stimuli applied simultaneously to the same side, and (5) tests of perception with mixed stimuli applied to corresponding areas on the two sides of the body. Most of the conventional tests for sensation were used.

The test stimuli used, in so far as possible, were applied with equal intensity. For testing pain modality, algesimeters graduated to apply pressures of from 2.5 to 25 Gm. with a no. 10 needle point, were employed. A two point compass was frequently used for simultaneous stimulation of corresponding parts of the trunk and for testing "two point sensibility." For fine tactile sensation, horsehairs and wisps of cotton were employed. Finger touch, rubbing and scratching were used for testing superficial tactile sensation. A tuning fork of 256 double vibrations per second served for testing vibratory sense. Thermal sensibility was tested by immersion of the extremities in bowls of water at 40 and 140 F. and with test tubes containing water at the same temperatures. In testing graphesthesia, the following figures were drawn on the skin with a pencil point: *3, 4, 5, 9, E, S,* a circle, a square and a triangle. Barognosis was tested with metal weights of 1, 2 and 3 pounds (0.5, 0.9 and 1.3 Kg.). To test stereognosis, a key, a book of matches, a 25 cent piece and a pencil were placed in the patient's hands. For discrimination of texture, paper, glass, rubber, cloth, leather, wool and metal objects were employed. For testing point localization, the patient was asked to touch with his finger the spot previously touched by the examiner. A pencil was drawn across the skin in straight and wavy lines and in various directions. The patient was asked to describe the type and direction of the lines drawn. Temporal relationships for sensory adaptation were measured in seconds with a stopwatch.

For testing auditory sense, sounds were produced by crumpling paper, jingling keys and clinking test tubes. These sounds were made in front of, behind and

3. Dusser de Barenne, J. G., and McCulloch, W. S.: Factors for Facilitation and Extinction in the Central Nervous System, J. Neurophysiol. **2**:319-355 (July) 1939.

to either side of the patient. Since the visual acuity of our patient was extremely poor, it was impossible to test visual extinction.

REPORT OF A CASE

History.—The patient, a Hungarian-born elevator operator aged 57, had been in perfect health until about Aug. 6, 1946, when he first noticed headache in the right temporal area. This rapidly increased in severity and radiated to the right orbit and deep into the right ear. About August 20 he noticed weakness of his left leg and left arm. He was admitted to another hospital on August 27. There he was found to have a "mental change" (not otherwise described), but was not completely disoriented and was not aphasic. He had bilateral papilledema of 2 to 3 D., hypesthesia of the left side of his face, a diminished left corneal reflex, slight weakness of the left lower part of the face, tremor of the left hand, a tendency to fall to the left and astereognosis on the left side. The results of laboratory studies, including examinations of the spinal fluid, were reported as normal. The electroencephalogram, the roentgenogram of the skull and ventriculograms all suggested a lesion of the right parietal area. This diagnosis was confirmed by operation on September 7, when part of a large glioblastoma multiforme was removed. It was located deep in the right temporal lobe, with wide extension deep into the right parietal and frontal areas. The region of the hypothalamus and ventromedial surface of the right temporal lobe were also involved. After operation the patient made an uneventful recovery. He was transferred to Bellevue Hospital on September 25.

Neurologic Status.—The findings in this hospital were essentially the same as those previously reported; in addition, pronounced left hemiparesis was noted, as well as the presence of Babinski's sign bilaterally and a tendency on the part of the patient, to bring the fingers together well to the left of the midline when instructed to join fingers with his eyes closed. Confrontation tests suggested homonymous left hemianopsia. Roentgenograms of the skull and other laboratory studies contributed no new information. An electroencephalogram, made on Oct. 7, 1946, showed irregular, slow waves in the right frontotemporal and motor areas and, in addition, potentials of diminished amplitude in the left motor and the right postparietal and occipital regions. High voltage roentgen therapy to the head was begun on October 14 and given daily for six weeks, during and after the tests described in this paper.

Psychiatric Studies.—The patient's personality was found to be well within the normal range of integration. His appearance was neat and his behavior quiet and well mannered. For the first few days after admission, he remained in bed most of the day and engaged in little spontaneous speech. Since then, he has been up and about the ward and has quickly formed friendships with other patients. His physical condition and future plans he discussed freely and eagerly with the physicians on the service. His speech showed no retardation or increase in psychomotor activity. Replies to questions were clear, concise, coherent and relevant. His mood was not depressed at any time, and he was ever grateful for the many routine and special examinations performed toward the complete work-up of his case. At no time did his thought content show evidence of hallucinations, delusions, obsessions, compulsions, persecutory trends, grandiose ideas or other disorders. The sensorium was clear. Orientation was correct for time, place and person. Except for amnesia for the period just preceding his operation, there was no loss of memory for recent or remote events. Calculation and recall were intact, but he fatigued after a fairly short period of examination. His fund

of general knowledge showed no impairment. Judgment and insight were preserved.

Special psychologic examinations, which consisted of the Wechsler-Bellevue intelligence scale and the Rorschach test, were administered. With these tests the patient earned a verbal intelligence quotient of 84. Because of his poor vision, he was unable to handle any of the performance test items. Since he received a zero score on all the nonverbal items, the intelligence quotient obtained could not be considered to be his true one. On the verbal section of this test, his lowest scores were obtained in items involving arithmetical calculations and memory span. The pattern on the latter was typical of diffuse organic damage, for he exhibited ability to repeat digits forward and total disability to repeat digits backward.

His performance on the Bender gestalt test again indicated an organic disturbance. His forms were completely disorganized and showed a tendency to regress to primitive loops irrespective of the shape of a given figure. Pronounced fatigability and dissociation on the motor level were evident. The patient's ability to organize visual *Gestalten* was completely impaired.

Sensation.—The patient at no time complained of sensory disturbances on the left side of his body. It was noticed, however, that in response to commands he would ignore the left side of his body. When told to extend his arms, he would invariably extend only the right arm. On second command to extend both arms, he would then bring up his left arm. When told to flex his knees, he would flex only his right knee.

Sensory defects, except for those of vibratory sense and graphesthesia, were limited to the left side of the body. Pain sensation was not lost but remained active and equal on the two sides. Thermal sensation showed a pronounced dissociation of perception of hot and cold stimuli. Cold sensation was normal over the entire left side. Heat sensation was normal over the head, neck, shoulder and palm on the left side, but showed delayed and diminished perception in the extremities. This was especially so in the lower left extremity.

Pain sensation was not lost on the left side, where acuity of pain was equal to that on the right side. However, pain perception on the left side showed a diminished adaptation time[4] as compared with that on the right side. When a weighted pin of 20 Gm. was applied continuously to the right knee, the pain would disappear entirely in an average of six seconds. The same stimulus applied to the left knee yielded a perception of pain which was entirely gone in an average of two seconds, demonstrating that the sensory adaptation time was greatly reduced on the affected side, particularly in the distal portions of the extremities. Superficial tactile sense, tested by finger touch and horsehair touch, revealed diminished perception on the left side. Superficial tactile sense on the dorsum of the right hand disappeared in seven seconds, whereas on the dorsum of the left hand it disappeared in three seconds.

Vibratory sense was impaired on both sides. It was found that kinesthetic sense, i. e., appreciation of passive movements, was intact on the right side. It was greatly impaired, however, on the left side, and the patient was completely unable to detect gross movements of the fingers and wrist. Knowledge of spatial position of the hand and forearm was lacking on the left side. Stereognosis, while intact on the right side, was lost in the affected (left) hand. Texture discrimination

4. Bender, M. B.: Changes in Sensory Adaptation Time and After-Sensation as Symptoms of Parietal Lobe Lesion, Arch. Neurol. & Psychiat. **55**:299-319 (April) 1946.

showed severe impairment to absolute loss on the left side. Barognosis was not disturbed on either side. Graphesthesia was severely impaired on both sides of the body. Point localization was fairly accurate throughout the cutaneous area tested. Two point discrimination, however, revealed a constant diminution over the entire left side.

Sensory Adaptation Time.—Sensory adaptation time, as described here, refers to the time interval required for the characteristic sensation of a continuing stimulus to disappear. All sensations show this phenomenon of negative adaptation. The modalities of pain, touch and temperature showed a reduction in adaptation time on the affected side. No after-sensations were observed. Fluctuation phenomena were a fairly constant feature in these tests, and the patient showed easy fatigability during the procedures.

Sensory Extinction Phenomenon.—The patient perceived in a normal manner all modalities of sensation (except virbratory sensation and graphesthesia) on both sides of his body provided the two sides were tested separately. If, however, "double stimulation" was used, that is, if the same type of stimulus was applied simultaneously to corresponding parts (cutaneous areas) of the two sides of the body, the stimulus on the right side extinguished that on the left, so that the patient was aware only of stimulation on his right side. The patient denied perceiving a stimulus on the left side even if specifically questioned about what he felt on his left side. In a few tests, however, he remarked that he felt a faint stimulus on the affected side. Even when the stimulus on the left side was far stronger than that on the right, the stimulus on the right side usually extinguished that on the left.

The same phenomenon was observed when double stimulation with hot and cold stimuli was tested. A hot stimulus on the right would extinguish a hot or cold stimulus on the left. Tests for barognosis also brought out the extinction phenomenon. With double stimulation, a weight in the left hand was either not perceived at all or erroneously interpreted.

This phenomenon was observed not only when similar types of stimuli were applied to corresponding sides but also when mixed stimuli were used. Thus, a painful stimulus on the left side was not perceived if a simultaneous tactile stimulus (rubbing) was applied on the right. Similarly, a pinprick on the right side extinguished perception of a weight in the left hand.

Detailed Presentation of Sensory Findings.—(*a*) Perception of Pinprick: The first modality tested was perception of pinprick. When such a stimulus was applied separately to either side of the body, the patient was able to appreciate immediately a sharp point. He was thus able to perceive a pinprick applied anywhere on his body surface.

When pinpricks were applied simultaneously to corresponding areas on the right and the left side (except for the head), the sensation was perceived on the right side only. If, for example, the right and the left hand were simultaneously stimulated with pinprick, the patient would state, "I feel a pinprick in the right hand." Even when his attention was specifically directed to his left hand, he still asserted that he felt a pinprick in the right hand only.

Unequal stimuli were used by varying the pressures in the needle algesimeters employed. In all trials in which the stimuli were applied to the dorsal areas of the hands and feet, the forearms, thighs and legs, pain sensation on the left side was extinguished when a painful stimulus was applied simultaneously to a corresponding part on the right side. This was true even when the stimulus applied to the left side was far greater than that applied to the right side. For example,

a pressure of 25 Gm. applied with the algesimeter to the left hand was not felt at all when a pressure of 5 Gm. was simultaneously applied to the right hand.

Adaptation time was tested with a continuing stimulus. With a pressure of 20 Gm. applied with the algesimeter to the right knee, pain was reported to have disappeared after an average of six seconds. On the left knee, pain disappeared after an average of two seconds.

(*b*) Tactile Sense: This modality was first tested by touching the patient with the examiner's finger. The patient was able to perceive and identify correctly a touch applied anyhere on his body surface. When, however, tactile stimuli were applied simultaneously to corresponding areas on the right and left sides, the sensation was perceived on the right side only. The same phenomenon was observed when mixed stimuli of pain and touch were employed. When pain and touch stimuli were applied simultaneously to corresponding areas on the two sides of the body, pain caused extinction of tactile perception on whichever side it was applied.

The adaptation time for finger touch was less on the left side than on the right; whereas the sensation of touch was reported to have disappeared within an average period of seven seconds on the dorsum of the right hand, it disappeared within an average period of three seconds on the dorsum of the left hand.

A wisp of cotton was then used for testing fine tactile sensation. Perception of this stimulus was immediate when applied anywhere on the right side of the body. On the left side, however, a delay between application of the stimulus and its perception was consistently noted. For example, the delay for the dorsum of the left hand averaged two seconds; for the left side of the chest, three seconds; for the left leg, ten seconds, and for the small toes of the left foot, seven seconds. An incidental finding with cotton wool was allachesthesia. When the dorsum of the left hand was stroked with cotton wool, the patient reported feeling the stimulus on the dorsum of the opposite hand.

Fine tactile sense was tested also by means of horsehairs. As before, a delay in perception was present on the left side. Double stimuli applied to the right and the left sides of the nose, tongue and lips produced sensory extinction on the left side in each case.

Finally, tests were made by the examiner's rubbing or scratching the patient's skin with his finger. When both the patient's hands were simultaneously scratched or rubbed, he reported feeling a scratching or rubbing on the right hand and nothing on the left. The stimulation was then stopped on the right side, and the patient, within an average period of seventeen seconds, reported feeling the stimulus on the left.

(*c*) Thermal Sense: Perception of temperature was tested in two ways: 1. Test tubes containing water at 40 and 140 F. were applied to various areas of the skin. It was found that the patient could perceive accurately either stimulus when applied singly to any part of the body. With double stimulation, hot test tubes being applied to each side, sensory extinction occurred on the left side, and the patient felt only the stimulus on the right. This was true whether the double stimuli were hot or cold. With mixed stimuli extinction again occurred. A hot test tube on the right forearm extinguished the perception of a cold test tube on the left forearm. Similarly, a cold test tube on the right thigh extinguished the perception of a hot test tube on the left thigh.

2. Bowls of water at 40 and 140 F. were employed for immersion of the hands and feet. With this method it was found that sensory extinction occurred on the left side, but only when mixed stimuli were employed. When double stimuli

were applied, the patient felt correctly the stimuli on both sides, whether hot or cold. It is probable that his perception of wetness of the skin accounted for his seeming ability to perceive double stimuli.

Perception of temperature showed delay on the left, or affected, side for heat only. Cold was felt immediately on both the left and the right side.

(*d*) Barognosis: Weight discrimination was tested, using weights of 1, 2 or 3 pounds (0.5, 0.9 or 1.3 Kg.). A weight placed in either hand alone was perceived and correctly interpreted. When equal weights were placed in the two hands simultaneously, they were correctly perceived. When, however, unequal weights exceeding 1 pound were placed in the two hands simultaneously, the phenomenon of extinction appeared. For example, if 3 pounds was placed in the right hand and 1 pound in the left hand, the patient perceived the weight in the right hand only and said that his left hand contained "nothing, or maybe a piece of cloth." If the heavier weight was placed in the left hand, however, no extinction occurred.

Tests were also made using mixed stimuli simultaneously, e. g., pinprick on one side and weight on the other. These tests showed that pinprick on the right side caused the patient to be unaware of, or to misinterpret, a weight placed in the left hand. When the weight was placed in the right hand and a pinprick was applied to the left side, both stimuli were correctly interpreted. This showed that pain sensation was too strongly maintained on the left to be easily extinguished.

Adaptation time for perception of a weight placed in the hand showed a difference between the right and the left hand. The patient was immediately aware of a weight placed in either the right hand or the left hand alone. In the right hand, the patient ceased to be aware of the presence of the weight within sixteen seconds, on the average, after it had first been placed in the hand. In the left hand, however, he ceased to be aware of the weight stimulus after an average adaptation time of eleven seconds. The duration of extinction after withdrawal of the extinguishing stimulus was also measured. Thus, if stimuli were applied simultaneously to the two hands but the stimulus on the right was removed after five seconds, the patient did not become aware of the continuing stimulus on the left until about seven seconds after withdrawal of the stimulus on the right. This was true when different modalities were used on the right and on the left side.

(*e*) Two Point Discrimination: Two point discrimination is also described as a function of the parietal region. Discrimination was tested over the hands, forearms, chest, abdomen, thighs and legs. Throughout these areas, the left side showed a higher threshold for the perception of a double stimulus; that is, a greater distance between the two points was required for them to be perceived as such on the left side. The following tabulation shows the minimal separation necessary for two points to be perceived as such rather than as one stimulus only.

	Right (Cm.)	Left (Cm.)
Finger tips	Less than 0.3	Less than 0.3
Dorsum of hand	2	2.5
Palm	0.6	2.5
Dorsal surface of forearm	2	2.5
Arm	1.3	2.5
Chest	1.3	3.8
Abdomen	1.3	3.8
Thigh	2	2
Inner surface of thigh	2	2
Leg	2	3.8

(*f*) Stereognosis: Stereognosis was intact on the right side and severely impaired on the left. When objects were simultaneously placed in the two hands,

the patient correctly named the object in the right hand but denied the presence of anything in the left hand.

(*g*) Texture Discrimination: This modality was tested by use of coins, paper, glass, leather, wood, cloth and rubber. The patient's perceptions were correct on the right side but were entirely incorrect on the left side.

(*h*) Graphesthesia: Graphesthesia was tested by drawing the following figures on the skin: a circle, a square, a triangle and E, S, 4, 5, 3 and 9. It was found that the patient was unable to interpret correctly on either side of the forehead or on the forearm, hand, thigh or leg on either side.

(*i*) Vibratory Sense: Vibratory sense was tested with a tuning fork with a frequency of 256 double vibrations. Entirely contradictory reports were given on the two sides.

(*j*) Direction and Type of Lines: Lines were drawn on the skin, longitudinally, tranversely and in a wavy manner. These lines were drawn with a pencil over various parts of the body. The patient was able to interpret correctly the direction and type of line throughout.

(*k*) Auditory Extinction: An attempt was made to demonstrate the presence of auditory extinction. Sounds were produced by crumpling paper, jingling keys or clinking test tubes. It was found that the patient could lateralize sounds perfectly whether the sound stimulus came from one side alone or from the two sides simultaneously. Double stimuli and mixed stimuli were used, but in no instance was the extinction phenomenon produced.

(*l*) Visual Extinction: Owing to the extreme impairment of the patient's visual acuity, visual extinction tests were not attempted.

COMMENT

In this patient it has been demonstrated that sensory function of the left side of the body was in many respects normal and intact. Perception on the left is unimpaired provided the right side of the body is not simultaneously stimulated. If this is done, the patient is made unaware of even strong stimulation of his left side. A lesion of the right cerebral cortex has somehow brought about a change in the patient's perception of his environment in that he is unable to perceive simultaneous sensations of stimuli on opposite sides of the body.

Failure to perceive certain stimuli is, of course, a constant process in the normal human being. The passage of air in and out of the nasopharynx in respiration, the pressures of clothing, the sounds of traffic in the street to the office worker intent on his task—all are stimuli not perceived unless attention is specifically drawn to them. The nature of this "drawing of attention" cannot be explained, although Heyman's law suggests that when a strong and a weak stimulus are applied to the organism simultaneously, the stronger stimulus inhibits the weaker one. Apparently, however, it is this "attention" factor that is involved in our patient's symptom. Stimuli entering the intact cortex of the left hemisphere alter the patient's consciousness of his environment in such a manner that stimuli entering the right cortex are not perceived. What is dealt with here is, in fact, a subtle and slight alteration in the consciousness of the patient. This alteration in consciousness differs, perhaps, only quantitatively from the much larger alterations, up to complete "unconsciousness," of certain more extensive lesions of the brain. The phenomenon here discussed emphasizes the functional integ-

rity not only of the brain but of the body and indicates the impossibility of explaining the relationship of various parts of the body by the present structural understanding of neuroanatomy and neurophysiology.

Another finding in our patient was the change in the sensory adaptation time on the affected left side. This, too, is an alteration in consciousness, though of a different type. The normal subject becomes unaware, or unconscious, of any continuing stimulus after a length of time varying with certain conditions, such as type and intensity of the stimulus. In our patient, this "unconsciousness" occurs consistently sooner on the affected side. What connection this fact may have with the phenomenon of extinction is not clear; it can only be said that the two apparently result from the same lesion.

The defects in two point discrimination, stereognosis, texture discrimination and kinesthetic sensory perceptions on the left side are consistent with the observations reported by Head in his studies of lesions of the parietal lobe in man.[5]

SUMMARY

A patient with partial surgical excision of the right frontoparietotemporal cortex is described. He was able to perceive correctly on the right side of the body all sensory modalities except vibration and graphesthesia, which were impaired. The left side showed accurate perception for the sensations of pain, touch and temperature; barognosis, and point localization, with impairment in perception of fine tactile sense, position sense, vibration, graphesthesia, stereognosis, texture and two point discrimination.

The phenomenon of extinction was demonstrated for the sensory modalities of pain, touch and temperature and barognosis. This was done by the application of double stimuli and mixed stimuli simultaneously to corresponding sides of the body. In all these tests, the affected (left) side of the body exhibited extinction of the cutaneous sensations aforementioned. The implication of these findings and the possible explanations are briefly discussed.

5. Head, H.: Studies in Neurology, London, H. Frowde, 1920.

News and Comment

CERTIFIED BY
THE AMERICAN BOARD OF PSYCHIATRY AND NEUROLOGY, INC.

The following candidates were certified at a meeting of the board in New York, Dec. 15 to 17, 1947.

Psychiatry.—David Abrahamsen, New York; Henry Holmes Babcock, Providence, R. I.; Jerome S. Beigler, Chicago; John Berghorst, Traverse City, Mich.; Albert M. Biele, Morristown, Pa.; Lee Coulthard Bird, Concord, N. H.; Bertha Blumer, Downey, Ill.; Robert Dunlap Brookes, St. Louis; DeWitt C. Brown Jr., Central Islip, N. Y.; James E. Brown, Ogdensburg, N. Y.; Leonard Cammer, New York; Jack Chernus, Newark, N. J.; Edwin L. Demuth, White Plains, N. Y.; Frank A. Donaldson, Cedar Grove, N. J.; John J. Dorey, Utica, N. Y.; Harold H. Dubner, Chicago; Frederick Douglas Dudley, Philadelphia; George Fenyes, Chicago; Marshall Louis Fisher, Palo Alto, Calif.; Theodore C. C. Fong, Washington, D. C.; John Alfred Frank, New York; Philip L. Franklin, Gary, Ind.; William Kirksey Freeman, Los Angeles; Stanley W. Geshell, Denver; Delmar Goode, Chicago; Soll Goodman, New York; Mary Malinda Gorton, Gary, Ind.; Robert J. Hall, Wassaic, N. Y.; Edward Lee Hammond, New York; Thomas J. Hardgrove, Waco, Texas; Ralph Nathaniel Harris, Togus, Maine; Thomas Anthony Harris, Washington, D. C.; Charlotte Ellen Hellmer, Norristown, Pa.; Frank R. Henne, Marcy, N. Y.; David William Hilger, Topeka, Kan.; *Alfred H. Hill, San Antonio, Texas; Harry G. Hockett, Marion, Ind.; Robert James Hudson, Pittsburgh; Harriet Hunter, Denver; Eugene Richard Inwood, Washington, D. C.; Benjamin F. Jackson, Fort Lyon, Colo.; James S. L. Jacobs, Clifton Springs, N. Y.; P. M. Jerrell, Murfreesboro, Tenn.; William Cecil Johnston, Beacon, N. Y.; Frederic T. Kapp, Cincinnati; Douglas McGlashan Kelley, Winston-Salem, N. C.; George H. Kohlbraker, Norristown, Pa.; Isadore Kotzin, Coatesville, Pa.; E. Ross Laughlin, Willard, N. Y.; Oscar Legault, Washington, D. C.; Roland Allen Leslie, Cincinnati; William Libertson, Rochester, N. Y.; Pasquale D. Lotesta, Brooklyn; Wilbur M. Lutz, Wernersville, Pa.; Malcolm Yeaman Marshall, Murfreesboro, Tenn.; Irwin Mason, Flushing, N. Y.; David Mendell, San Francisco; Alvin Francis Meyer, New York; George I. Meyer, Roanoke, Va.; Alva Edward Miller, Denver; George Ensley Moore, Milwaukee; Marlin C. Moore, Coral Gables, Fla.; Simon H. Nagler, New York; Sam Nelken, New Orleans; Louis William Nie, Indianapolis; Samuel J. Obers, New York; *Veronica O'Brien, Valhalla, N. Y.; Stanley L. Olinick, Washington, D. C.; Francis John O'Neill, Central Islip, N. Y.; Eli Holmes Orr, Fort Custer, Mich.; William David Pace, Boston; Peter A. Peffer, Roanoke, Va.; Harvey Elmore Pinto, San Jose, Calif.; Joseph E. Pisetsky, New York; Oscar Mandel Plotkin, Elgin, Ill.; Marion Ballard Richmond, Washington, D. C.; Joseph M. Rom, Towson, Md.; Harold Rosen, Baltimore; *Herman Michael Rosow, West Los Angeles, Calif.; William Rottersman, North Little Rock, Ark.; Charles Saltzman, Brookline, Mass.; Solon David Samuels, New York; Arthur Walter Schappell, New York; Julius Seidman, West Los Angeles, Calif.; William M. Shanahan, Honolulu, Hawaii; Joseph Slutzky, Eloise, Mich.; Gerald Walker Smith, Mare

*The asterisk denotes complementary certification.

Island, Calif.; Herbert Spiegle, Kew Gardens, N. Y.; Walter David Steed, Omaha; Morton M. Stern, Newark, N. J.; Harold Stevens, Washington, D. C.; Thomas William Sugars, Seattle; Gabriel Charles Sutch, Middletown, Conn.; Richard Lee Sutherland, Topeka, Kan.; Norman Taub, Washington, D. C.; Joseph David Teicher, New York; Earley Thomas Terrell, Richmond, Va.; John Wakeman Turner, Fayetteville, N. C.; Samuel Allen Victor, Chicago; Maxmilian Weinberger, Waverley, Mass.; George J. Weinstein, New York; Frederick Lawrence Weniger, Pittsburgh; Robert Allen Wetzler, Washington, D. C.; Carl Wiesel, Lexington, Ky.; Charles Henry Wiggins, St. Louis; Herman Herbert Willner, Northport, N. Y.; Leon L. Willner, Beacon, N. Y.; Joseph F. Zigarelli, Greystone Park, N. J.; Harold Zobel, Northport, N. Y.; Max Zuger, Woodmere, N. Y.

Neurology.—Eugene Willard Green, Staten Island, N. Y.; Ernest Macfarlane Hammes, St. Paul; Ralph William Hunter, Hanover, N. H.; * Henry Ambrose Kildee, Fort Custer, Mich.; Ilya Mark Scheinker, Cincinnati; Martha R. Westerberg, Ann Arbor, Mich.

Psychiatry and Neurology.—Howard Dixon McIntyre, Cincinnati; Christian F. Midelfort, La Crosse, Wis.; Benjamin Wiesel, New York.

WESTERN SOCIETY OF ELECTROENCEPHALOGRAPHY

The Western Society of Electroencephalography held its first scientific meeting at Toland Hall, University of California Hospital in San Francisco, on Nov. 8, 1947.

A constitution was adopted which offers active membership to physicians actively engaged in the field of electroencephalography. Investigators in related scientific fields are eligible for associate membership.

The following officers were elected: Robert B. Aird, M.D., San Francisco, chairman; Knox H. Finley, M.D., San Francisco, vice chairman; Nicholas A. Bercel, M.D., Los Angeles, secretary-treasurer.

The program committee comprises Knox H. Finley, M.D., San Francisco, chairman; Robert B. Aird, M.D., San Francisco; Nicholas A. Bercel, M.D., Los Angeles; Hale Haven, M.D., Seattle; Robert S. Dow, M.D., Portland, Ore.

The membership committee consists of Henry Newman, M.D., San Francisco, chairman; John Moriarty, M.D., Los Angeles, vice chairman; Robert B. Aird, M.D., San Francisco; Knox H. Finley, M.D., San Francisco; Nicholas A. Bercel, M.D., Los Angeles.

The next meeting will be held in San Francisco on April 10 and 11, 1948, directly preceding the annual meeting of the California Medical Association. Those wishing to contribute presentations are invited to communicate with the member of the program committee in their area. Those interested in joining the society can secure application blanks from the secretary-treasurer, Dr. Nicholas A. Bercel, Cedars of Lebanon Hospital, Los Angeles.

Obituaries

CLARENCE O. CHENEY, M.D.

1887-1947

Clarence O. Cheney, medical director emeritus of the New York Hospital-Westchester Division, White Plains, N. Y., professor of clinical psychiatry in Cornell University Medical College and consulting psychiatrist to the New York Hospital, died of a cerebral hemorrhage at the White Plains Hospital in White Plains, N. Y., on Nov. 4, 1947, at the age of 60.

He was born in Poughkeepsie, N. Y., on July 10, 1887 and received his early education in that city. He entered Columbia College, New York, from which he was graduated in 1908 with the degree of Bachelor of Arts. He studied medicine at Columbia University College of Physicians and Surgeons, from which he was graduated in 1911. In the same year he became a member of the staff of the Manhattan State Hospital on Ward's Island and from 1912 to 1917 was assistant physician and pathologist at that hospital. During that period he performed 800 autopsies, in which he made gross and microscopic examinations of organs, with emphasis on the study of the central nervous system, together with clinical and pathologic correlation of material. He did research in epilepsy, cerebral arteriosclerosis, dementia paralytica and changes in the nerve cell associated with dementia precox.

From 1917 to 1922 he was assistant director of the New York State Psychiatric Institute, then on Ward's Island. He was active in teaching and administration and did special research in the relation of focal infection to mental disorders. His contributions to the psychiatric literature showed his broad and intensive interest in the field of his work.

Dr. Cheney was assistant superintendent of the Utica State Hospital, Utica, N. Y., from 1922 to 1926, and while there he made special studies of the malarial treatment of dementia paralytica. Not limiting his work to the hospital, he became actively interested in bringing psychiatry to the community.

From 1926 to 1931 he was medical superintendent of the Hudson River State Hospital. On leaving this post, which was in the city of his birth, he was called back to his alma mater and to the institute where he had previously worked. Dr. Cheney was medical director of the New York State Psychiatric Institute and Hospital in New York city from 1931 to 1936, and from 1932 to 1936 he was professor

of psychiatry and executive officer of the department of psychiatry of the College of Physicians and Surgeons of Columbia University. He also directed the clinical and research work of that psychiatric center.

From 1936 to 1946 he was medical director of the New York Hospital-Westchester Division, White Plains, N. Y. His administration in this institution was marked by improvements in the service to disturbed and newly admitted patients. He directed the construction of new buildings for the care of acutely disturbed women patients and for physical therapy. He made special studies on the results of nonspecific treatment of dementia precox and encouraged the careful application of shock therapy in the treatment of mental disorders. He stimulated the staff to greater efforts in clinical research and continued his interest in the psychiatric problems of the state and the community.

Dr. Cheney was a member of the medical board of the New York Hospital. He was consulting psychiatrist to the White Plains Hospital, White Plains, N. Y.; Grasslands Hospital, Valhalla, N. Y.; St. Luke's Convalescent Hospital, Greenwich, Conn.; Northern Westchester Hospital, Mt. Kisco, N. Y.; Vassar Brothers Hospital, Poughkeepsie, N. Y., and Bellevue Hospital, New York.

Dr. Cheney was a fellow of the American Psychiatric Association, which he served as secretary and treasurer from 1928 to 1933 and as president in 1935-1936. He was fellow of the American College of Physicians, the American Medical Association and the New York Academy of Medicine. He was president, from 1933 to 1935, of the New York Society for Clinical Psychiatry. He was a senior member of the New York Neurological Society and served as president of the New York Psychiatric Society in 1943-1944. He was a member of the Association for Research in Nervous and Mental Disease, of the New York State Medical Society and of the Westchester County Medical Society, and was president of the Dutchess County Medical Society in 1927-1928. He was corresponding member of the Royal-Medico Psychological Association of England. Dr. Cheney was an organizer and charter member of the American Board of Psychiatry and Neurology. He was appointed a member of the Temporary Commission on State Hospital Problems by Governor Lehman and was an active member of the National Committee for Mental Hygiene and of the State Mental Hygiene Committee of the State Charities Aid Association. He served on the Mayor's Committee of White Plains on Post-War Planning and was director of the Westchester County Mental Hygiene Association. He was associate editor of the *American Journal of Psychiatry* and of the *Psychiatric Quarterly*. He made many valuable contributions to the advancement of psychiatry, published scores of articles, edited the "Outline for Psychiatric Examinations" and contributed to medical texts and reviews.

Dr. Cheney was a member of the local draft board of New York city in 1917-1918. He served as psychiatrist to the Medical Advisory Board of Westchester County from 1942 to 1945 and was awarded the Congressional Selective Service medal in 1945. Since 1945 he had served as senior consultant in psychiatry to the Veterans Administration at the New York regional office, New York city.

He was a member of Sigma Xi and Alpha Omega Alpha, and in 1944 he was awarded the University Medal by Columbia University for professional distinction and public service.

Dr. Cheney was a member of the White Plains University Club and the Rotary Club.

In 1915 he married Josephine Scott, who survives him with a son, Robert Scott Cheney.

Such a strong and vigorous leader commanded the respect and admiration of all who knew him. His integrity, loyalty and unstinted devotion to duty as an administrator, teacher and physician were an inspiration to all associated with him in the many hospitals, schools and organizations which he served, and in the communities in which he lived.

J. H. WALL, M.D.

JAMES STUART PLANT, M.D.

1890-1947

James Stuart Plant was born in Minneapolis, Aug. 1, 1890. He died suddenly at his home in South Orange, N. J., on Sept. 7, 1947. His fifty-seven years of life included a vast amount of sympathetic understanding of the problems of his fellow human beings, of well directed study to elucidate such troubles, of treatment to alleviate them and of wise use of all available sources of relief. He never looked robust but preferred to carry himself as one in quite adequate health. He said little about the warnings that his circulatory system was impaired. Ten years ago it was necessary for him to be in bed for a while, but he was up as soon as possible. After ending his recent vacation, he appeared well and seemed to feel fairly comfortable and vigorous. His sudden death, therefore, though perhaps it might have been expected, was a surprise to those closest to him.

As a boy, he came east for his education. He received the degree of Bachelor of Arts in 1912 at Hamilton College, which institution gave him also an honorary doctorate of science in 1938. Going to the University of Pennsylvania, he won the degrees of Master of Science in 1913 and of Doctor of Medicine in 1918. He was elected to Phi Beta Kappa and Sigma Xi. During the years of medical study, 1914 to 1918, he was also an assistant in the Pennsylvania Hospital for Mental Diseases. After a rotating internship in Lancaster, he went to Massachusetts, where he worked in the Boston Psychopathic Hospital.

Going abroad, Dr. Plant was resident physician at the American Hospital, Neuilly, France, in 1919-1920. During these months he studied psychology at the Sorbonne and neurology in the current clinics.

Returning to Massachusetts, he became pathologist at the McLean Hospital for two years. Concurrently, he was an assistant in neuropathology in Harvard Medical School. Then he joined the Judge Baker Foundation Children's Clinic for a part of 1922 and 1923. Thus was completed an admirable preparation for the important work of the next twenty-four years.

Essex County, New Jersey, established the first tax-supported juvenile clinic in the country; this followed a demonstration clinic in Newark, fostered by the National Committee for Mental Hygiene and served by local psychiatrists. Dr. Plant became the first director of the juvenile clinic in April 1923 and held the post to the end of his career. At the time the clinic was founded, forward-looking people were thinking

largely in terms of the prevention of delinquency, and of the cure of delinquency when it had occurred. Accordingly, such a clinic at the outset had its principal connection with the juvenile court, and in many years that court referred more cases than any other agency. But other social agencies expected help. Relations were early established with the schools, and, as time went on, requests came largely from troubled parents, sometimes without their having sought advice either from school or court.

This is not intended to be a history of the Juvenile Court of Essex County, but one may comment on Dr. Plant's method of operation. He always had a small staff. He preferred to do his own routine psychologic examinations as a part of his study of his young patients. Nevertheless, in 1929 he added a psychologist to the staff to work in a group of schools. Back in 1926 a visiting teacher had been engaged. From 1924 to 1933 other physicians assisted in the clinic. He believed in many clinics scattered through the county and without central control, and succeeded in getting several set up and working. Such arrangements were widely admired and imitated.

He was unselfish, gentle and kind, not only understanding the troubles of his patients, but also appreciating the difficulties of a society made up of imperfect people with a great variety of ideas about how the world should be run—people who often strove for the best, but not infrequently contented themselves with much lower ideals. He was skilful in presenting both sides of a social situation and in helping his listeners to see how it comes about that perfection is not quickly attained. He cultivated diction that might be easily understood by the lay groups in his county who called on him for addresses—parents, parole officers and teachers. He could hold any audience but preferred to discuss matters with small groups. Not only did he make understandable the immediate situation but he also showed what road should be followed to better the life and conduct of the child under discussion. The child that had been studied was turned back to the referring agent for treatment.

Dr. Plant soon became an important force in the community where he lived, and later in other sections of the country, where he emphasized so lucidly the importance of social forces in the development and deviation of human conduct. He was in great demand as a lecturer and became as well known in distant parts of the land as close at home. All but three states of the United States invited his addresses. He conducted courses in mental hygiene at New York University, Columbia, Dana, Rutgers, Montclair State Teachers' College and other schools.

Having no desire to build a private practice, his arrangement with the county was that his own judgment should decide how much he could be away. He organized his appointments skilfully so as not to be

overwhelmed by a sudden rush of cases or to be out of town for periods that would impair the work of the clinic. Out of his large experience and the careful development of his theses in lectures, he published in 1937 a volume (Personality and the Cultural Pattern, London, Commonwealth Fund, 1937) which is authoritative wherever children are studied. Another book is on the point of coming off the press, and a third was in his mind to develop during the next year or so.

Dr. Plant's attitude toward others was one of genuine interest, with no assumption of prerogative. One person said, reminiscently, that Dr. Plant talked to her "as if she were the only person that he was interested in that morning." Obviously, it was quite impossible for him to accept all calls for advice and collaboration, or even to join all the medical societies that invited him, but he was always helping some important organization. For the last several years he had taken time to be chairman of the executive committee of the National Committee for Mental Hygiene, a post of national importance. He accepted also the chairmanship of a committee of the American Psychiatric Association which engaged, with a similar committee of psychologists, in the formulation of standards of training in the realm of clinical psychology.

Dr. Plant married Mildred Stuart Heller in 1919. He thoroughly enjoyed his home, and during his last vacation had done in the yard a piece of work in which he took justified pride. The house was full of music on his days at home. Since he was naturally somewhat shy, many acquaintances did not realize his love of music or his fine fund of humor. Those who admired and revered him were legion.

SAMUEL W. HAMILTON, M.D.

Abstracts from Current Literature

Physiology and Biochemistry

HEMODYNAMIC AND BIOCHEMICAL CHANGES IN DOGS SUBJECTED TO SECTION OF THE SPINAL CORD. L. EICHELBERGER, C. H. LAESTAR and D. B. PHEMISTER, Arch. Surg. **51**:42 (July) 1945.

Five dogs surviving the circulatory embarrassment resulting from section of the spinal cord at the eighth cervical segment were studied for varying periods after the recovery period to determine changes in blood pressure, hemoglobin content, red cell count and erythrocyte volume and biochemical changes in the serum and erythrocytes. Loss of blood was not a factor in the experiments.

The blood pressure fell promptly after section of the spinal cord to values of 60 to 80 mm. of mercury, at which level it persisted for four to six days, without resulting in circulatory failure. It then rose slowly to 90 to 100 mm. of mercury during the subsequent two weeks and to the vicinity of 120 mm. of mercury in six weeks. The biochemical changes in the blood determined from the fourth postoperative day to a time when the blood pressure returned to the preoperative level were characterized by (1) a slight hemodilution, as evidenced by lowered serum proteins, little alteration in the serum chloride, water and sodium and increased plasma volume; (2) significant increases in the potassium of the serum as long as the oxygen content of the blood was low, and (3) pronounced decreases in the cell volume (hematocrit reading), cell count and oxygen content of the blood for three to four weeks after operation.

The improvement in the anemia and the anoxia occurred simultaneously with the elevation of blood pressure.

The cause of the pronounced reduction in the red cell count and erythrocyte volume (hematocrit reading) and the oxygen content of the blood under conditions of paralysis from section of the cord at the eighth cervical segment and of the prolonged lowering of the blood pressure is not well understood. It is to be sought in the following factors: (1) trapping of red blood cells in the capillaries and blood reservoirs; (2) increase in plasma volume; (3) increased rate of destruction of red cells, of an undetermined cause; (4) undernourishment, and (5) possibly, retardation of hemopoiesis by the low blood pressure despite the presence of anemic anoxia.

Comparable findings in clinical cases of injury high in the spinal cord would call for appropriate medicinal therapy and blood transfusions for rehabilitation of the blood. LIST, Grand Rapids, Mich.

EFFECT OF NICOTINIC ACID AMIDE [NICOTINAMIDE] AND SODIUM ON GLYCOLYSIS AND OXYGEN UPTAKE IN BRAIN HOMOGENATES. E. RACKER and I. KRIMSKY, J. Biol. Chem. **161**:453, 1945.

The glycolytic activity of brain tissue is rapidly lost on destruction of its cell structure. Geiger found that when brain cells are disrupted with distilled water an inhibitor of glycolysis is released. By simply diluting a water extract of rat brain, he reduced the effect of the inhibitor and obtained a rate of production of lactic acid from glucose far exceeding the values obtained with brain slices or brain dispersions. Two factors inhibiting glycolysis have been found in mouse brain homogenates. One of these is diphosphonucleotidase, the enzyme acting on diphos-

phonucleotide, which can be counteracted by addition of nicotinamide, as demonstrated by Mann and Quastel. The second inhibitor was found to be Na^+, which can be counteracted by phosphocreatine. The preparation of mouse brain homogenates, capable under anaerobic conditions of producing from glucose 7.5 mg. of lactic acid per hundred milligrams wet weight of brain per hour and having an oxygen uptake of 20 to 30 cu. mm. per milligram per hour is reported.

PAGE, Cleveland.

CENTRAL NERVOUS SYSTEM RESISTANCE: 1. THE EFFECTS OF TEMPORARY ARREST OF CEREBRAL CIRCULATION FOR PERIODS OF TWO TO TEN MINUTES. ROBERT GORDON GRENELL, J. Neuropath. & Exper. Neurol. **5**:131 (April) 1946.

In this series of experiments, adult dogs of both sexes were subjected to complete arrest of cerebral circulation for two, four, six, eight and ten minutes. It is felt that with the method employed complete cerebral anemia is assured. An appreciable difference in circulatory arrest was noted in various areas of the brain, and a certain degree of local selectivity or specificity of lesions was evident. There appears to be a gradient of resistance, which from the lowest to the highest degree is as follows: cerebral cortex (isocortex); cerebellar cortex (Purkinje cells); sensory and integrative centers of the brain stem, pons and medulla oblongata; cerebral cortex (allocortex), and, finally, large motor cells of the brain stem, pons, medulla oblongata and spinal cord. It is felt that since the lesions in many cases appear restricted to anatomic units (nuclei), these groups may be not only morphologic but also metabolic units. Grenell points out that the extreme sensitivity of the brain to ischemia and anemia is of great clinical importance and that lesions observed clinically are often similar to those reported here. It is important, however, to consider the technic used as a tool in the study of electrical and metabolic changes of the brain under conditions of increasing severity of anemia and blood stasis. Such studies, it is hoped, will lead not only to information of clinical value but also to data clarifying the basic relationships between abnormalities of structure and those of function.

GUTTMAN, Philadelphia.

CONVULSIVE EFFECTS OF ANTIBIOTIC AGENTS ON THE CEREBRAL CORTEX. A. EARL WALKER, HERBERT C. JOHNSON, THEODORE J. CASE and JERRY J. KOLLROS, Science **103**:116 (Jan. 25) 1946.

Clinical and experimental studies on animals and man indicate that penicillin may produce convulsions when applied to the cerebrum. The authors found an abnormal electroencephalographic pattern in more than 60 per cent of 51 cases in which penicillin was given parenterally for illnesses other than primary disease of the central nervous system. Control records obtained before and after penicillin therapy usually showed normal electroencephalograms. Large doses of penicillin injected intrathecally in man (40,000 units) or the monkey (10,000 units) may give rise to generalized convulsions, followed in some cases by coma and death. The application of as little as 250 units of penicillin to the cerebral cortex of the macaque monkey may induce epileptic attacks. These convulsive phenomena are not due to impurities in the preparation, for they have occurred with penicillin made by ten different manufacturers and with purified crystalline penicillin.

Streptomycin applied to the cerebral cortex of cats and monkeys in doses of 1,250 units induced convulsive manifestations in 30 per cent of cases. Electroencephalographic records at such times showed slow waves and spikes, with subsequent decrease of cortical activity, lasting from one to three hours. Cisternal injection of 2,500 units of streptomycin in the monkey induced signs of severe cerebellar dysfunction.

Streptothricin applied to the parietal cerebral cortex in doses of 5,000 to 10,000 units produced clinical and electroencephalographic convulsive manifestations. Although these phenomena usually disappeared spontaneously in two to three hours, in 2 monkeys they persisted for two weeks. Necropsy revealed extensive softenings with perivascular petechial hemorrhages in the brains of the affected animals.

Actinomycin injected into the cerebral cortex or cisterna magna in a dose of 1 mg., after a latent period of nine hours produced severe prostration, fasciculations and convulsions, with death in one to seven days. At the site of injection into the cerebral cortex a severe necrobiotic reaction, with edema and petechial hemorrhages, was observed.

Clavacin, when injected into the cerebral cortex in doses of 5 to 10 mg., induced clinical and electroencephalographic manifestations of convulsive phenomena, with a decided decrease in spontaneous electrical activity of the brain.

There appears to be a relatively wide margin of safety between the antibiotic concentration and the convulsive threshold of penicillin and streptomycin. Such does not appear to be the case for streptothricin, clavacin or actinomycin.

GUTTMAN, Philadelphia.

FORMATION OF ACETYLCHOLINE IN CELL-FREE EXTRACTS FROM BRAIN. W. FELDBERG and T. MANN, J. Physiol. **104**:8, 1945.

Feldberg and Mann confirm the observation of Nachmansohn and Machado (1943) that homogenized brain tissue synthesizes acetylcholine anaerobically in the presence of adenosine triphosphate and choline. Scarcely any acetylcholine was formed under aerobic conditions. The enzyme system, which catalyzes the formation of acetylcholine, has been separated from the particulate matter of brain and obtained in the form of cell-free solutions, prepared by extraction of acetone-dried and powdered brain (rat) in saline solution. The formation of acetylcholine in such extracts was better in anaerobic than in aerobic conditions. In one hour, at 37 C. 140 to 400 micrograms of acetylcholine was formed anaerobically by the extract obtained from 1 Gm. of acetone-dried and powdered brain, but only half this amount was produced aerobically. Reduced glutathione and cysteine strongly activated the aerobic formation of acetylcholine. On the other hand, oxidized glutathione and cysteine inhibited both the aerobic and the anaerobic formation of acetylcholine. Thus, adenosine triphosphate and sulfhydryl (SH—) compounds are both essential for the aerobic formation of acetylcholine. The breakdown of adenosine triphosphate in the extract from the brain-acetone powder has been followed in the course of the synthesis of acetylcholine. Adenosine triphosphate could not be replaced by adenosine diphosphate, inosine triphosphate or adenylate. The formation of acetylcholine was inhibited in the presence of dextrose, fructose and certain phosphohexoses. The effect of sugars was found to be due to an enzymic esterification of the labile phosphate groups of adenosine triphosphate. The formation of acetylcholine was enhanced by K ions and diminished by Ca ions.

THOMAS, Philadelphia.

RESTING AND ACTION POTENTIALS IN SINGLE NERVE FIBRES. A. L. HODGKIN and A. F. HUXLEY, J. Physiol. **104**:176, 1945.

Hodgkin and Huxley describe a technic for introducing microelectrodes into the interior of giant axons from the squid (Loligo forbesi). Action potentials recorded externally were not affected by the introduction of a microelectrode

100 microns in diameter. The action potential recorded across the surface membrane was not altered by changing the fluid surrounding the fiber from oil to sea water. The amplitude of the action potential was found to be about twice that of the resting membrane potential. The largest action potentials recorded were about 90 microvolts, whereas the corresponding resting potentials were about 45 microvolts. All measurements were made with a microelectrode containing sea water at its tip, so that there must have been a junction potential between the axoplasm and the microelectrode. The true resting potential across the surface membrane was probably about 60 microvolts. Measurements with external electrodes were made on single nerve fibers from crabs (Carcinus maenas) and lobsters (Homarus vulgaris), as well as on axons from the squid. These results showed that the action potential was about 75 per cent greater than the injury potential produced by an isotonic solution of potassium chloride. The difference between the action potential and the true resting potential must have been greater than this, since isotonic solution of potassium chloride itself reverses the membrane potential. The difference between action and resting potentials is too large to be explained by a liquid junction potential between the axoplasm and the microelectrode. It must be due to a genuine reversal of potential at the surface membrane of an active section of nerve. Possible ways in which this reversal of potential might arise are discussed.

THOMAS, Philadelphia.

EFFECT OF INTRODUCTION OF ISOTONIC SODIUM CHLORIDE SOLUTION INTO THE CISTERNA MAGNA OF THE DOG ON THE CELL CONTENT OF THE CEREBROSPINAL FLUID. T. H. B. BEDFORD, J. Physiol. **104**:299, 1946.

Bedford made a study of the effect of introduction of isotonic solution of sodium chloride into the cisterna magna on the cell content of the cerebrospinal fluid of dogs anesthetized with pentobarbital sodium. The duration of each experiment was approximately five hours. Polymorphonuclear leukocytes, generally unaccompanied with other reactive cells, were present in the cerebrospinal fluid at the end of 9 out of 13 experiments. The introduction, under the same conditions, of Ringer's solution—Dale's formula (Burn, J. H., and Dale, H. H.: Pituitary Extracts, Medical Research Council, Special Report Series, no. 69, London, His Majesty's Stationery Office, 1922)—or of distilled water into the cisterna magna did not cause reactive cells to appear in the cerebrospinal fluid.

THOMAS, Philadelphia.

FACTORS INFLUENCING THE FORMATION OF ACETYLCHOLINE IN CELL-FREE EXTRACTS FROM BRAIN. W. FELDBERG and T. MANN, J. Physiol. **104**:17P, 1946.

Both homogenized brain tissue (Nachmansohn and Machado, 1943; Nachmansohn, John and Waelsch, 1943) and cell-free extracts prepared from acetone-dried brain (Feldberg and Mann, 1944) contain an enzyme system which synthesizes acetylcholine provided adenosine triphosphate is added.

Recently, however, Feldberg and Mann succeeded in showing that adenosine triphosphate is not an irreplaceable component of the synthesizing system. An equally large formation of acetylcholine could be obtained both aerobically and anaerobically if, instead of adenosine triphosphate, citrate and boiled juice from brain were added. The boiled juice was fully active only in the fresh state. The activator present in it is not identical with either adenosine triphosphate or choline. Whereas the activating effect of adenosine triphosphate on the formation of acetylcholine is reversed by glucose, owing to the esterification of the labile

phosphate groups of adenosine triphosphate, the synthesis of acetylcholine in the presence of citrate and boiled juice is not influenced by glucose.

If all three activators, adenosine triphosphate, citrate and boiled juice, were added together to the brain extract, the rate of formation of acetylcholine rose to 1,200 micrograms (rat) and 1,800 micrograms (guinea pig) per gram of acetone powder per hour, at a temperature of 37 C. This is the highest rate hitherto observed. Other corresponding average figures for rat and guinea pig, respectively, are 300 and 700 micrograms per gram with adenosine triphosphate alone, 700 and 900 micrograms with adenosine triphosphate and boiled juice and 1,000 and 1,200 micrograms with adenosine triphosphate and citrate.

Citric acid could not be replaced by succinic, fumaric or tartaric acid. Malonic, glutamic and aconitic acids had only a slight activating effect. Malonic acid did not inhibit the action of citric acid.

On dialysis, the brain extract lost the ability to form acetylcholine. Its activity, however, could be restored with citrate and boiled juice added together, or by citrate and adenosine triphosphate added together, but not by citrate alone or by the boiled juice alone.

THOMAS, Philadelphia.

Psychiatry and Psychopathology

THERAPEUTIC ROLE OF DRUGS IN THE PROCESS OF REPRESSION, DISSOCIATION AND SYNTHESIS. LAWRENCE S. KUBIE and SYDNEY MARGOLIN, Psychosom. Med. **7**:147 (May) 1945.

Kubie and Margolin point out that the processes of repression, dissociation and synthesis, which are the operating concepts in the genesis and therapy of the neuroses, are applicable to the patient under drugs such as the barbiturates, derivatives of cannibis, scopolamine, alcohol and the volatile anesthetics.

These drugs lower the intensity of the repression to such unpleasant emotions as rage, anxiety and guilt, thus permitting the exploration of the repressed and dissociated psychologic experiences. For the same reason, the patient is able to accept and integrate interpretations without catastrophic disturbances.

The authors believe that these facts permit the use of drugs in dynamic psychotherapy to circumvent resistances.

WERMUTH, Philadelphia.

ON THE EFFECTS OF SUGGESTION IN TREATMENT OF VASOSPASTIC DISORDERS OF THE EXTREMITIES. MACK LIPKIN, ELLEN MCDEVITT, STEPHEN SCHWARTZ and A. WILBUR DURYEE, Psychosom. Med. **7**:152 (May) 1945.

Lipkin, McDevitt, Schwartz and Duryee treated 9 patients with vasospastic disorders by means of suggestion in the form of an impressive, but pharmacologically impotent, apparatus. This was sometimes accompanied with verbal suggestion of impending therapeutic benefit. Six of the patients showed pronounced subjective and slight objective improvement.

Some patients had relief of the vasospasticity for several years. It was noted that cutaneous temperature sometimes changed rapidly under emotionally charged stimuli. Cold was found sometimes to be less important than psychic trauma in precipitating acute spasm. Some of the patients showed periods of increased symptoms when they were psychologically traumatized in the home environment.

The authors state that their studies emphasize the need of adequate control in therapeutic studies of vascular disorders in which spasm plays a part.

WERMUTH, Philadelphia.

IDENTIFICATION MECHANISMS IN CORONARY OCCLUSION. JACOB A. ARLOW, Psychosom. Med. **7**:195 (July) 1945.

The usual story of the patient with disease of the coronary arteries is that of a stubborn, self-willed child who early entered into competitive relationship with a much feared and envied parent. Conflict was then repressed and identification made with this parent. Through hard work, self discipline and compulsive devotion to the termination of the task which he assigns to himself, the patient keeps driving himself to success. A masochistic trend is noted in the manner in which such a patient neglects himself and makes himself martyr to his own ideals. Superficially he appears entirely outgoing and self reliant.

Arlow points out that this personality pattern may be extremely rewarding from the social standpoint, but it offers the patient little happiness and solves few of his problems in a satisfactory manner. The compulsive striving for achievement and mastery never seems to end. The author studied 9 cases to determine how these adaptive mechanisms fail. He said that these patients make a spurious, and only partial, identification with the father. The image of the father is exaggerated out of all proportion by the childhood anxiety. This identification is made less out of admiration and more out of fear; the identification is not complete and thoroughgoing, and in the deeper layers of the personality it is unconvincing. This deep-seated lack of conviction accounts for both the compulsive competitiveness and the traumatic effect of the experience of failure. With inward feelings that he is a sham, the patient cannot accept success. But it is not simply the experience of failure which proves so traumatic to the patient with coronary disease. What disturbs him most is to fail in the role of his major identification and to fail in circumstances that convince both the outer world and himself that he was not so good as he thought.

WERMUTH, Philadelphia.

PSYCHOSOMATIC REGRESSION IN THERAPEUTIC EPILEPSY. THOMAS D. POWER, Psychosom. Med. **7**:279 (Sept.) 1945.

Power studied the convulsions induced in the treatment of mental disorder in the light of Hughlings Jackson's belief that an epileptic fit resulted in the process of nervous dissolution, a "taking to pieces" of the nervous system in the reverse order to that of evolution. The author found that there was regression both in the somatic and in the psychologic fields. Somatic regression showed itself first by the initial start or series of starts which resemble the Moro reflex of infancy. This is followed by tonic and clonic spasms, which the author compares to the sustained and jerky movements that have been described as occurring in the developing sheep fetus. It is interesting that in the sheep fetus the movements become inhibited as development proceeds but that under the influence of asphyxia they can be reactivated in the reverse order of that in which they evolved. Power suggests that during the dissolution of therapeutic convulsion a similar process of reactivation of fetal movements occurs. After the termination of the convulsion, but before consciousness returns, behavior patterns of infancy may be observed. These include sucking movements, the performance of various antics and baby's crying.

Psychologic regression is noted still later in recovery, when it is possible to establish some rapport with the patient. There are signs of aphasia. When the patient is asked to write various things, such as his address, he frequently will give an address where he had resided in childhood, suggesting that he is living in the past. This tendency to slip back into the past is displayed throughout the whole period of recovery, but the patient may also, to a certain extent, be living in the

present, leading to a fusion of psychic material, so that composite formation appears. Preservation and repetition are also invariably present and may be exhibited at the reflex level in the form of a sustained or repetitive type of knee jerk. In the post-convulsive state there is retrograde amnesia, and during recovery events which are more remote in time are remembered before more recent happenings.

WERMUTH, Philadelphia.

THE NEUROPSYCHIATRIC ASPECTS OF PORPHYRIA. NATHAN ROTH, Psychosom. Med. **7**:291 (Sept.) 1945.

Roth studied 10 cases of porphyria and concludes that the disease occurs with special frequency, if not exclusively, in people with severe neurotic personality disorders. Patients usually appear to be hysterical, except in those cases in which involvement of the brain by the disease clouds the underlying features of the personality. The author further believes that the psychoneurosis plays an important part in the pathogenesis of the disease. In 7 of the 10 cases which he reports, there was a history of major psychosis or serious deviation of personality in one or more members of the last three generations of the family.

The peculiarities of the tendon reflexes constituted a striking feature of the symptomatology of the acute attacks in the cases described. The ankle jerks were present, but often the knee jerks were absent. The latter, however, could frequently be elicited if the tendon was repeatedly tapped. There was also great variability in the activity of the reflexes from time to time.

In 4 of the cases described all the clinical neuropsychiatric symptoms of porphyria were exhibited, but porphyrins were not found in the urine.

WERMUTH, Philadelphia.

A STUDY OF HOMOSEXUAL ADULT MALES. E. L. SEVRINGHAUS and JOHN CHORNYAK, Psychosom. Med. **7**:302 (Sept.) 1945.

Sevringhaus and Chornyak assayed the urine of 20 adult males with overt homosexuality for total neutral 17-ketosteroids and pituitary gonadotropins and compared the results with a series of controls. Half the homosexual subjects had no demonstrable gonadotrophic hormones in their urine. The other 10 members of the homosexual group showed excretion of gonadotrophic hormones comparable to that in the control group. Six of the homosexual patients had less and 6 had more 17-ketosteroids than had any one of the controls. The authors conclude that their data do not lead to any explanation of homosexual behavior but that they do add to the conviction that there is an endocrine disturbance accompanying such behavior in many cases.

WERMUTH, Philadelphia.

Neuropathology

TWILIGHT STATE WITH INTENSE EXCITEMENT FOLLOWING THALAMIC DISEASE. H. WALTHER, Monatschr. f. Psychiat. u. Neurol. **111**:1, 1945-1946.

Walther reports a case in which a twilight state resembling acute catatonic excitement was associated with focal disease of the left thalamus. A man aged 52 had sudden onset of right hemiplegia, which improved gradually during the next few months. Two years later he had an attack of unconsciousness, followed within a few hours by an epileptiform seizure and a confused state. The blood pressure

was 220 systolic and 120 diastolic. After three weeks the mental symptoms suddenly became very severe. The patient showed constant motor unrest, attempting to get out of bed, grabbing or striking at persons and crying and shouting meaningless sounds. His speech was incoherent and fragmentary. At times his behavior suggested completely unmotivated, blind rage. This condition continued for three weeks, except for one day during which he was in a cataleptic state. Thereafter he became quieter, but he still exhibited confusion and unintelligible speech. He grew increasingly inactive and apathetic. Death occurred with signs of cardiac failure almost two months after onset of the acute mental disturbances. Examination of the cerebral cortex failed to reveal any abnormalities. The left internal capsule showed an old area of softening on an arteriosclerotic basis and the left thalamus a more recent one, which was judged to be between two and three months old. The latter lesion was located in the caudal half of the thalamus, involving part of the nucleus lateralis principalis and the dorsolateral portion of the pulvinar. According to Walther, this case indicates the need of broadening one's concepts of the clinical disturbances associated with thalamic disease. He believes that the well known thalamic syndrome, characterized by sensory and motor abnormalities and painful sensations, occurs only when the ventral portion of the lateral nucleus is affected. Lesions in other areas of the thalamus can apparently produce mental disturbances, the more complete investigation of which requires additional observations. ROTHSCHILD, Worcester, Mass.

Meninges and Blood Vessels

SEQUELAE OF CEREBROSPINAL MENINGITIS: AN ANALYSIS OF SIXTY CASES. S. I. BALLARD and H. G. MILLER, Lancet **2**:273 (Sept. 1) 1945.

The material on which the authors made their study consisted of 60 patients referred to a neuropsychiatric center of the Royal Air Force after attacks of cerebrospinal meningitis. Fifty-three showed symptoms, these being severe in 23, moderately severe in 23 and mild in 7. Most of the patients were seen three to six months after the acute illness. Of the 53 patients with symptoms, the outstanding complaints were headache in 34; lassitude in 7; backache in 3, and "effort" symptoms in 3. The symptoms, listed in order of their frequency of occurrence, were headache, failure of concentration, backache, insomnia, depression, postural dizziness, symptoms of impaired ocular function, muscular pains in the limbs, effort symptoms, poor memory, dyspepsia and vertigo. Full neurologic examination revealed organic signs in only 7 patients. One had palsy of an external rectus muscle; 2, diplopia, lasting for several weeks but finally clearing up; 1, facial palsy; 1, transient weakness of ocular convergence, and 1, persistent unilateral tinnitus with slight nerve deafness.

The authors believe that the determining factors in the severity and persistence of the subjective residual symptoms following cerebrospinal meningitis were in direct relation to the severity of the acute illness and more strikingly, to the degree of psychoneurotic predisposition, as determined by the personality study. Of 49 patients treated with superficial psychotherapy and graduated exercises, 45 were returned to duty and 4 were invalided. None of the 49 patients had neurologic signs of an organic lesion. The authors suggest that the symptom complex following cerebrospinal meningitis should be regarded as a psychosomatic reaction. Suggestion, whether coming from a physician or from others, played a significant part in the production and perpetuation of symptoms. YASKIN, Camden, N. J.

RELAPSING FEVER WITH NEPHRITIS AND SUBARACHNOID HEMORRHAGE. H. A. DEWAR and R. WALMSLEY, Lancet **2**:630 (Nov. 17) 1945.

Relapsing fever, as seen during the war in the armed forces in the Middle East, was almost entirely a tick-borne disease. Small rodents and some larger mammals, especially, perhaps, jackals, provide the animal reservoirs from which the various species of Ornithodoros ticks reinfect themselves with the spirochete. Infection of man is an occasional accident. Dewar and Walmsley report the case of a man who was infected with the organism of relapsing fever, Leptospira icterohaemorrhagica. After only one bout of fever, nephritis and severe epistaxis supervened. Death took place, apparently during the phase of remission of the fever, as the result of a subarachnoid hemorrhage. Necropsy revealed hemorrhage at the base of the brain, which was limited by the membranes of the subarachnoid space and had taken place but a short time before death. Microscopically, the most striking features of the nephritis was its intensely hemorrhagic character. The picture suggested a general hemorrhagic tendency, of which perhaps the epistaxis and the perirenal and subarachnoid hemorrhages may be regarded as other manifestations.

YASKIN, Camden, N. J.

Vegetative and Endocrine Systems

UNILATERAL LACRIMATION ASSOCIATED WITH CHEWING. I. B. BENDER, Am. J. Orthodontics **31**:692 (Nov.) 1945.

Bender reports a case in which stimulation of the anterior palatine pad area brought about only congestion, lacrimation and pain. The effects were best produced by rubbing with a finger or by pressure from a denture during mastication. While the symptoms could be produced by reading small print and blowing the nose, the dental complaint was the more important. The pad area was definitely localized as the trigger point by the fact that unilateral biting and movements of the muscles of mastication did not reproduce the syndrome. When there is independent biting, either on the right or on the left side, there is no compression or rubbing on the pad area. With normal chewing the force of mastication produces pressure because of the closeness of adaptation of the dentures on the yielding mucosal tissues. This case differs from those reported in the literature in that, associated with lacrimation, there were congestion and pain. Whether this can be attributed to stimulation of both the autonomic and the sensory systems is difficult to say.

J. A. M. A.

RELATION OF THE DIENCEPHALIC-HYPOPHYSIAL SYSTEM AND THE DIGESTIVE APPARATUS. L. CAPRIGLIONE, J. SCHERMANN and M. C. SOUTO MAIOR, Arq. clin. **1**:105 (July) 1945.

One hundred and twenty-two patients with diencephalic and hypophysial disease were selected from the point of view of the incidence of gastrointestinal disturbances. Organic lesions of the gastrointestinal tract were observed in 3 patients with hypopituitary syndromes—gastroduodenitis with melena; gastritis, in 2 patients with Simmonds' disease, and a duodenal ulcer, in a hypophysial dwarf. Functional digestive disturbances were found in 56, or 47 per cent, of the remaining 119 patients. No other causes of the gastrointestinal disturbances could be found. Forty-six of the 103 patients with hypopituitary syndromes and 10 of the 19 patients with hyperpituitary syndromes showed functional gastrointestinal disturbances.

These disturbances were in the nature of constipation (26 per cent), anorexia (11.7 per cent), gastric malaise (10 per cent) and vomiting (10 per cent). The authors conclude that diseases of the pituitary-diencephalic system do not predispose to structural changes within the gastrointestinal tract. N. SAVITSKY, New York.

Treatment, Neurosurgery

STUDIES ON NEUROMUSCULAR DYSFUNCTION: NEOSTIGMINE THERAPY OF CHRONIC DISABILITY FOLLOWING FRACTURES. H. KABAT and C. W. JONES, Am. J. Surg. **71**:55 (Jan.) 1946.

Kabat and Jones report on neostigmine therapy of 51 patients for neuromuscular dysfunction resulting from trauma. Twenty-three of the 51 patients had fractures of the upper extremity, 17 had fractures of the lower extremity, 7 had fractures of the vertebrae and 4 had multiple fractures. Excluding the disabilities which had been present longer than five years, the average duration of the disability was 11.2 months. Of 20 patients who were given daily injections of saline solution for one week as a placebo, only 2 showed improvement. Neostigmine was usually administered for two to three weeks. This treatment resulted in significant improvement in 39 of the 51 patients. Of the remaining 12, 4 showed slight improvement, whereas the other 8 were without improvement. It has been possible to follow 27 of the 39 patients who showed significant improvement with neostigmine therapy for one to eight months after treatment was discontinued. All but 1 maintained the improvement after cessation of administration of the drug. The therapeutic value of neostigmine in the treatment of chronic disability following fractures emphasizes the important role of neuromuscular dysfunction in these disabilities. J. A. M. A.

PENICILLIN TREATMENT OF PNEUMOCOCCIC MENINGITIS IN INFANTS. G. HUTCHINS and J. A. V. DAVIES, J. Pediat. **27**:505 (Dec.) 1945.

Hutchins and Davies report 14 cases of pneumococcic meningitis in children under 2 years of age treated with penicillin. In 7 cases some form of sulfonamide therapy had been administered at various intervals before hospitalization. A number of the children were given sulfadiazine during hospitalization either for complications or for reasons associated with meningitis. The earlier patients and smaller infants were given penicillin intramuscularly on a dosage schedule of 3,000 units every three hours. The other patients were given 5,000 units every three hours. The schedule of intrathecal therapy was 10,000 units twice a day (or three times a day for the first few days) in an aqueous or saline solution containing 1,000 units per cubic centimeter. When blocks occurred so that spinal fluid could not be obtained by the lumbar route, penicillin was given intracisternally when possible and intraventricularly in a few cases. Penicillin was administered by the intrathecal route for an average of eleven days. Recoveries, either intact or with residual damage to the brain, were significantly more frequent with penicillin than with sulfonamide drugs and type-specific antipneumococcic serum. Of 14 infants, 9 survived. J. A. M. A.

THREE YEARS' EXPERIENCE WITH ELECTRIC CONVULSIVE THERAPY. JACOB NORMAN and JOHN T. SHEA, New England J. Med. **234**:857 (June 27) 1946.

Norman and Shea report the data obtained from a three year study of a series of patients in a state hospital who were given electric convulsive therapy. During

this period 266 patients were treated. The patients were classified on the basis of their diagnosis, as follows: schizophrenia, 175 patients; manic-depressive psychosis, 51 patients; involutional melancholia, 24 patients; psychoneurosis, 16 patients. The majority of the schizophrenic patients had been in the hospital for periods ranging from one to thirty years and showed definite "deterioration."

Three electric convulsive treatments a week was found to be suitable for most patients. The number of treatments given varied greatly. The acutely ill patients required a smaller number than did the patients with chronic disease. The patients with manic-depressive psychosis, depressed phase, and those with involutional melancholia required fewer treatments than did the patients in the manic phase of a manic-depressive psychosis. Schizophrenic patients in general required a larger number of treatments. If no improvement was noted after a series of twenty treatments additional therapy was not given, except in the case of 12 patients with chronic schizophrenia. These patients received fifty treatments. Whenever pronounced confusion was evident during the course of treatments, therapy was interrupted until the confusion had disappeared. The authors observed that in some cases a subconvulsive seizure delayed improvement.

In the patients with the depressed phase of a manic-depressive psychosis good results were obtained with an average of eight treatments. The patients with involutional melancholia required an average of fifteen treatments. The patients with manic-depressive psychosis, manic type, required an average of twenty treatments. For the patients with acute schizophrenia of sudden onset, ten to twelve convulsions sufficed. Chronic schizophrenia with an insidious onset was refractory to any number of treatments. Norman and Shea have had no experience in the use of combined electric shock and insulin therapy for chronic schizophrenia.

Of the 175 schizophrenic patients treated, 120 had been ill for one year or more, and 55 had been ill for less than one year. For the latter, the rate of remission was 62 per cent, with an average period of hospitalization of less than six months; for the former, the rate of remission was 7 per cent. For patients with manic-depressive psychoses, the rate of remission was 70 per cent, with the average period of hospitalization seven months. For patients with involutional melancholia, the rate of remission was 48 per cent, and for psychoneurotic patients, it was 80 per cent.

The length of the psychotic episode was definitely shortened, as is indicated by the figures for patients who were institutionalized prior to the use of electric convulsive therapy. It is stated that the period of hospitalization was less hazardous, and for patients with acute episodes the number of remissions was almost doubled.

The results of electroshock treatment of schizophrenia are generally good if treatment is instituted early in the disease and if the current attack is of sudden onset and does not show early severe regression. The authors are convinced that electric convulsive therapy is of little value in the treatment of chronic schizophrenia. They do not feel justified in treating 100 patients with the hope of obtaining a remission of the disease in 7. Electric convulsive therapy is of value as symptomatic treatment in chronic hospital cases presenting serious difficulties in management, provided that symptoms can be alleviated with a few treatments and that maintenance treatment is not required too frequently.

GUTTMAN, Philadelphia.

Encephalography, Ventriculography, Roentgenography

LUMBOSACRAL ROENTGENOGRAMS OF ONE HUNDRED SOLDIERS. M. M. FRIEDMAN, F. J. FISCHER and R. E. VANDEMARK, Am. J. Roentgenol. **55**:292 (March) 1946.

Roentgenographic examination of the lumbosacral region was made of 100 male soldiers without backache or history of injury to the back. The ages ranged from 19 to 39 years. The significant abnormalities and their distribution were as follows: defects in the pars interarticularis, 6 per cent; spondylolisthesis, 4 per cent; asymmetric facets at the lumbosacral articulation, 39 per cent; narrowing of the lumbosacral joint, 11 per cent; increased acuity of the lumbosacral angle, 2 per cent; osteoarthritis, 4 per cent; persistent centers of ossification of the inferior articular process, 2 per cent; sacralization of one or both transverse processes, 11 per cent; spina bifida occulta (fifth lumbar to fifth sacral), 36 per cent.

TEPLICK, Philadelphia.

THE OCCASIONAL APPEARANCE OF BOTH INNER AND OUTER SUTURE LINES IN ROENTGENOGRAMS OF THE SKULL SIMULATING FISSURE FRACTURES. GERHARD DANELIUS, Am. J. Roentgenol. **55**:315 (March) 1946.

Danelius notes that occasionally the suture lines in the outer table of the skull are serrated, whereas in the inner table they are straight. In roentgenograms of the skull the superimposition of the comparatively straight, inner suture on the serrated, outer suture is most frequently seen in the sagittal suture and the medial portions of the coronal and lambdoid sutures. The author warns against the erroneous diagnosis of a "fissure fracture of the skull running along the suture."

TEPLICK, Philadelphia.

ROENTGENOGRAPHIC SIGNS OF HERNIATION OF THE CERVICAL INTERVERTEBRAL DISK. J. E. WHITELEATHER, R. E. SEMMES and FRANCIS MURPHEY, Radiology **46**:213 (March) 1946.

The authors describe herniation of the cervical intervertebral disk as observed roentgenologically in 32 cases of the lesion verified by operation and in 106 additional cases not verified but presenting the same clinical and roentgenographic signs.

Small herniations are more likely to produce symptoms in the cervical region, for the spinal canal and the intervertebral foramens are smaller in this region than in the lumbar portion of the spine. Lateral protrusions on the nerve root can be divided into two distinct types: 1. Extruded nodules of the nucleus pulposus, which are soft and radiolucent but are easily recognized when the posterior ligament is incised. Later these nodules undergo ossification and may be interpreted as arthritic spurs. 2. Protrusions of the disk without rupture of the annulus fibrosus and without extrusion of the nucleus. Ossification occurs in the late stages.

Clinically, there is usually stiffness of the neck with pain radiating to the occiput; this pain may disappear and recur. Later, pain may be felt in the shoulder, over the anterior wall of the chest, along the medial border of the scapula and down the arm, being frequently accompanied with sensory changes in one or more fingers. Movement of the neck, coughing, sneezing and straining may aggravate the symptoms. Muscular and sensory changes are late, when present. The following abnormalities are observed in the roentgenogram: (1) loss or reversal of the normal cervical lordosis, either complete or segmental; (2) narrowing of the inter-

vertebral space; (3) calcified particles of the disk and proliferative spurs projecting into the foramen and from the anterior margins of the body; (4) alterations in size and shape of the foramen; (5) decreased mobility, and (6) defects in the myelogram.

None of the aforementioned signs is considered pathognonomic, and some may be present without sufficient injury to nerve to produce symptoms. Considered in conjunction with the history, symptoms and neurologic findings, the roentgenographic appearance is confirmatory. While myelographic examination commonly failed to reveal the lesion noted later at operation, the authors believe that myelography of the cervical region should be given a thorough trial.

TEPLICK, Philadelphia.

ROENTGENOGRAPHIC OBSERVATION IN AGE ATROPHY AND OSTEOPOROSIS OF THE SPINE. GOTTLIEB J. MARUM, Radiology **46**:220 (March) 1946.

Marum distinguishes between normal, uncomplicated atrophy of the bones due to age and osteoporosis. The latter when present usually gives rise to symptoms. The most important roentgenographic features of osteoporosis of the spine are: (1) more or less generalized atrophy and decalcification of bone; (2) a ground glass appearance of the vertebral bodies; (3) the fishbone type of vertebra, due to expansion of the intervertebral disk into the brittle and fragile vertebral body; (4) crushing, compression or fracture of the vertebral bodies, with secondary deformities, and (5) the kyphosis of the aged.

The author reports 10 cases and points out the occurrence of calcification in neighboring or distant organs in 8 of them. He suggests that the calcification may be due to the osteoporosis. The wall of the abdominal aorta was observed to be the site of calcification in 40 per cent of the cases; the intervertebral disk, in 30 per cent; the kidneys and spleen, in 20 per cent, and the uterus and other organs, in 10 per cent.

Osteoporosis of the spine is much commoner in women; all the patients in this series were women.

TEPLICK, Philadelphia.

Book Reviews

Dr. Kirkbride and His Mental Hospital. By Earl D. Bond, M.D. Price, $1.50. Pp. 163, with 5 illustrations. Philadelphia: J. B. Lippincott Company, 1947.

This is a homely and intimate story of one of the great figures of American psychiatry. Thomas Story Kirkbride turned from surgery to the care of the mentally sick and while still a young man took charge of a new development in hospital service in Philadelphia. He was a believer in the personal dignity of man even when the personality was disrupted by disease. He approached the problem not so much with investigative zeal as with a charming sympathy and attention to personal detail that won him a large following, not only among patients but also among his colleagues. Bond has given some intimate glimpses of the man and his work. Asking himself the question why Kirkbride was successful in his chosen field, he concludes: "The answer is that we are better scientists than Kirkbride and his friends, but not better people. We have machinery advanced and complicated beyond Kirkbride's wildest imaginations. But our relationships to our fellow men have not advanced. Kirkbride imagined far better things in the relationship of citizens to mental patients than the failures for which we are responsible. In a century it is doubtful if we have gained in the part of our minds where are stored our tangled loves and hates, our prejudices and our unreasoning emotions; it is doubtful if we have gained in self-discipline. So the present times cry for a woman like Dorothea Dix, a man like Thomas Kirkbride. Under leadership like theirs a State might turn to whole-hearted support of its mental hospitals, and, as it helped its suffering citizens, it would learn about human nature everywhere in business and in politics."

The plan and the propositions were Kirkbride's prime contributions to the care of the mentally sick. His planning is still to be seen in a number of large, solid, enduring institutions. The propositions are as good as any that could be laid down today. Bond tells the story in a simple and unaffected way that almost conceals the large amount of research into the historical background of which Philadelphians are justly proud.

New Fields of Psychiatry. By David Levy, M.D. Price, $2.75 Pp. 171. Chicago: W. W. Norton & Company, 1947.

This book is an outgrowth of the author's Salmon memorial lectures. It is an interesting, provocative and stimulating summary on what psychiatry has to offer beyond the psychopathic hospital. From the relatively old field of child guidance to industrial psychiatry and the most recent invasion of international politics, the psychiatrist has either spontaneously undertaken or been called on to make his contribution. Just what the psychiatrist has done and can do is discussed in the form of illuminating anecdotes based on the author's personal experience in these various fields.

Outstanding is the author's tribute to other agencies. He shows by case histories how psychologist, social worker and psychiatrist can effectively work as a team in studying a situation. This teamwork holds true in all new fields of psychiatry.

Political psychiatry is treated at great length. The methodology used in the evaluation of future leaders in Germany is clearly discussed. Despite the apparent

difference in the problems of denazifying Germany and those presented in understanding the mentally sick, psychiatrists will find the hurdle not too great. It requires the application of basic dynamic principles plus teamwork, initiative and research.

This book gives both stimulation and reassurance to those who are being called out of the psychiatric hospitals to do a much needed job in new fields of psychiatry.

Neuropathology. By I. Mark Scheinker, M.D. Price $6.75. Pp. 306. Springfield, Ill.: Charles C Thomas, Publisher, 1947.

This is the first of three planned volumes. It contains an up-to-date review of the most frequent neurologic syndromes and diseases. It is aimed to interest the general practitioner and the student of neurology and psychiatry. The second volume, which is in preparation, is an outline of neurosurgical neuropathology, and the third, to be called medical neuropathology, is dedicated to the neurologic complications of medical diseases. The reviewer wonders whether such a division is practically possible and advisable and whether the necessary connection with other branches of medicine can be maintained by this arrangement. A neurosurgeon should primarily be a good general neurologist, and some fundamental knowledge of general medicine and pathology is essential for every neurologist.

The chapters on diseases of vascular origin and on demyelinating processes are original and outstanding. The author shifts the emphasis in these processes quite convincingly from the arteries to the veins of the brain. Some important work on this subject is not cited. The clinical and statistical observations are based on old work without considering newer research. The chapters on neurosyphilis and inflammatory diseases are good without bringing any new views. The chapter on presenile and senile degeneration is less adequate, in comparison with other chapters. The book is written clearly, and the conclusions are well pointed out. The illustrations are good without being remarkable. The work will be reviewed in full when the other two parts are out.

L'acetilcolina nelle sindromi schizofreniche. Interpretazione patogenetica della dissociazione mentale e sua applicazione terapeutica. By A. M. Fiamberti. Pp. 454, with 10 illustrations. Price not given. Florence, Italy: Luigi Niccolai, 1946.

Fiamberti is director of the neuropsychiatric hospital at Varese; in 1937 he introduced the transorbital method of lobotomy. He states that in 1935 he produced convulsions in experimental animals by intracisternal injections of acetylcholine and in 1937 began treating psychotic patients by rapid intravenous injection of the same drug. He favors use of acetylcholine in shock therapy because of its theoretic implications, as well as its practical convenience and safety. In his monograph, which has a good summary in English, he reports results in 311 cases of schizophrenia. Follow-up studies of 120 cases at the end of four years show that the results are fairly stable. The rate of recovery was 68 per cent for persons sick less than one year, 28 per cent for those sick from one to three years and 17 per cent for those sick more than three years. Many of the patients whom the therapy failed to benefit were treated by other shock methods without appreciable effect.

After the rapid intravenous injection of 25 to 80 mg. of acetylcholine bromide (average dose, 50 mg.) there are momentary anxiety and then a sense of suffocation with dry cough and sudden loss of consciousness, followed by a brief and mild epileptiform seizure, accompanied with profuse lacrimation, salivation, pallor and sweating. Unconsciousness is necessary, but the seizure is not. Recovery is

rapid. No serious accidents have been encountered in the course of 26,000 injections. Injections are given six times a week for twenty doses and repeated after an interval of ten up to the limit of one hundred days.

Fiamberti stresses the fundamental importance of acetylcholine in neural transmission and believes that the injection of large quantities "stimulates and regulates the physiologic mechanism for the liberation of acetylcholine in nervous centers." He suggests that other shock therapies utilize the same mechanism, but in a nonspecific manner.

Approximately one hundred pages of the monograph are devoted to tabulation of data on individual cases, showing the usual distribution and characteristics of the schizophrenic population of a large hospital. Tuberculosis accounted for the death of 7 of the 20 patients who died from three months to five years after acetylcholine shock therapy. In no patient were there fractures, pulmonary infarcts or abscesses, cardiovascular disturbances or even painful arm from dislodgment of the needle. Spontaneous convulsions were rarely noted and were easily controlled. Most of the distress experienced by patients was concerned with respiratory embarrassment before unconsciousness developed. When the dose was insufficient to produce unconsciousness, the fear persisted. Fiamberti states that his method is applicable to inpatients rather than to outpatients, which suggests that it is rather disagreeable. This opinion is reenforced by excerpts from letters of a few patients The detailed tabulations do not show any clearcut advantage of acetylcholine over other shock methods so far as long term results are concerned. Probably the mildness of reaction and the absence of fractures are factors in its favor.

Hypnotism Today. By Leslie M. LeCron, B.A., and Jean Bordeaux, B.A., M.A., Ph.D., with a foreword by Milton H. Erickson, M.D. Price, $4. Pp. 278 plus ix. New York: Grune & Stratton, Inc., 1947.

The authors are two psychologists who, under medical supervision, have done considerable investigation of hypnotism. Their work involves research into the nature of hypnotism; a study of the mechanical factors, with a consideration of the best methods of inducing hypnosis, and an evaluation of hypnosis as a psychotherapeutic method, both alone and combined with other recognized technics. "The authors . . . are engaged professionally in daily psychotherapeutic work." In his foreword Dr. Erickson writes: "They have selected their material well, their exposition of it is excellent, and their presentation of their own studies is unassuming and straightforward."

The book "is intended to serve as a text for students, psychologists, psychotherapists and physicians." However, it is suitable also for the nonprofessional reader, since it includes chapters describing briefly the common psychiatric disorders and psychotherapeutic methods and is written in an easily readable style, with notable absence of technical terms. For the former group it contains a bibliography of sixty-three references, thirty-eight of which have been referred to in the text.

Although "hypnotic phenomena are little understood" and the book "is tinged with occultism," the authors have presented their material carefully, emphasizing the role of suggestion in hypnotism and stressing that "examples duplicating every phase of hypnosis can be found in the waking state of everyday life." Part 2 of the book is devoted to hypnotherapy, which the authors describe in detail, pointing out its great advantage in shortening the therapeutic procedure, when "there are fewer than four thousand psychiatrists" and "medical science is faced with a grave situation" with about 8,000,000 neurotic United States citizens today.

The book can be highly recommended.

Nutritional Disorders of the Nervous System. By John D. Spillane, M.D. Price, $5. Baltimore: Williams & Wilkins Company, 1947.

The book is a collection of observations based partially on the author's own experience during the war in the Middle East and among European prisoners of war camps. In addition to thorough clinical observations on deficiency diseases, it contains an excellent review of the literature. The literature is often considered to such an extent that it obscures the personal opinion of the author. At times greater clarity in selection from the abundance of facts and physiologic data could be desired. Summaries at the end of each chapter would help to make the study of this book easier; but that is a minor point, which does not detract from the value of the book. The study is a great contribution to the field of nutritional disorders of the nervous system.

Psychopathology: A Survey of Modern Approaches. By John Ernest Nicole. Edition 4. Price, $4.75. Pp. 268. Baltimore: Williams & Wilkins Company, 1946.

This is the fourth edition of this work on psychopathology by the medical superintendent of the Winwick Mental Hospital, England, first published in 1930. In his preface to this edition, the author states that only a few additions have proved necessary and that the bibliography has been brought up to date as far as possible. The preface to the first edition summarized the author's approach. "This handbook . . . is designed to provide a general survey of the views of the different schools of today, . . . to show some of the points at which different lines of approach approximate to one another, and to indicate, by references to important authors, directions in which further reading might prove profitable and interesting." He does succeed in summarizing concisely an enormous amount of literature. In this regard the book provides a useful source of bibliography for persons interested in one or more of the various schools of psychopathology. As a result of this devotion to a summary of the literature, however, the book tends to lack clarity and organization at many points, and to confuse the reader through successive rapid references to one author after another, with little integration of the various ideas. Many in this country would also quarrel with his apparent preference for the psychology of Jung and his dismissal of Adolf Meyer and psychobiology in one short paragraph, while devoting whole chapters to Rivers, Kempf and Berman.

Outline of the Spinal Nerves. By John Favill, A.B., M.D., F.A.C.P. Price, $3.75 Pp. 191. Springfield, Ill.: Charles C Thomas, Publisher, 1946.

The author employs the root-nerve-muscle-movement relationship as the basis of his outline. Each of four chapters is devoted to one of these factors. In addition to a complete and accurate anatomic and functional listing of all the roots, nerves and muscles Dr. Favill gives a concise clinical description of total and partial nerve lesions. The fifth chapter contains a consideration of the anatomic and clinical aspects of the brachial and lumbosacral plexuses, a discussion of the essentials of electrical testing of nerves and muscles, a short summary of the principal features of causalgia and several diagrams of the body dermatomes. This chapter adds nothing except to make the outline more complete.

Medical students and practitioners, especially those in the fields of neurology, orthopedics and physical therapy, may find this integrated outline of practical use as a source of quick reference.

MORTON NATHANSON, M.D.

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